Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JANUARY 1959

VOLUME 42 • NUMBER 1

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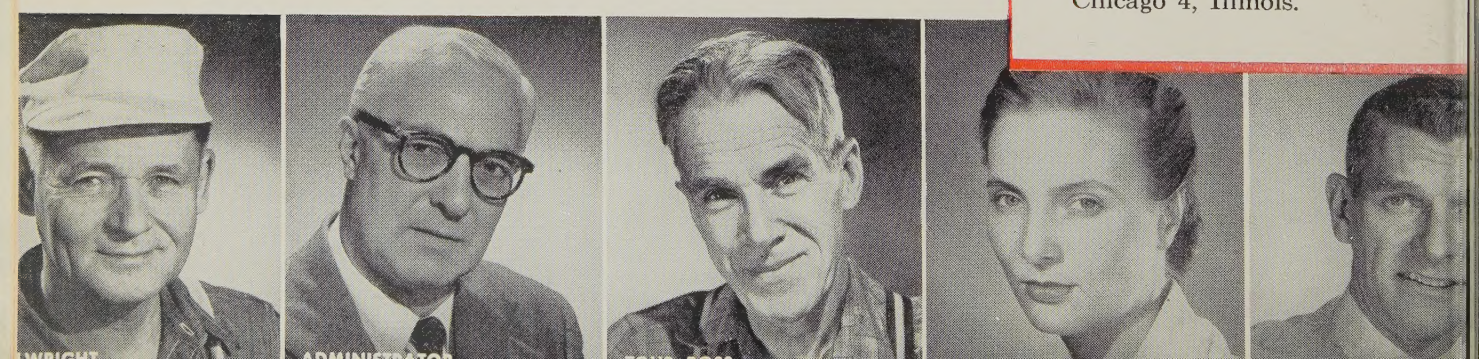
1. The contest is open to all employees of pulp and paper mills in North America.
2. Your paper should be confined to 1500 words, typed with double spacing on one side only of plain sheets, 8½" x 11".
3. Place your name, the name and address of your mill, your position or duties and your home address on the cover sheet only. This information must not appear in the manuscript.
4. Mail your entry before midnight March 31, 1959 to:
   The Secretary and Treasurer, The American Pulp and Paper Mill Superintendents Association, 327 So. LaSalle Street, Chicago 4, Illinois.



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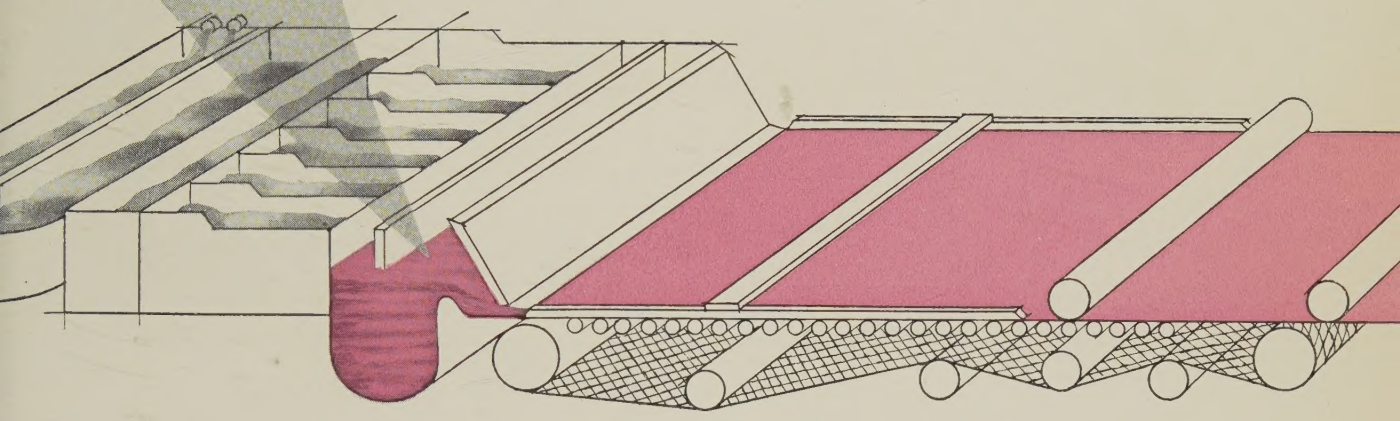

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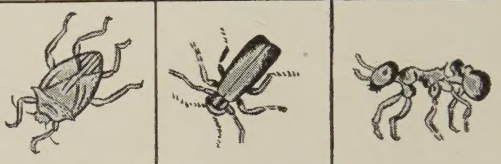
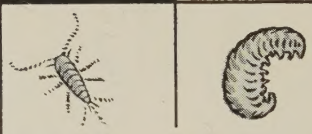
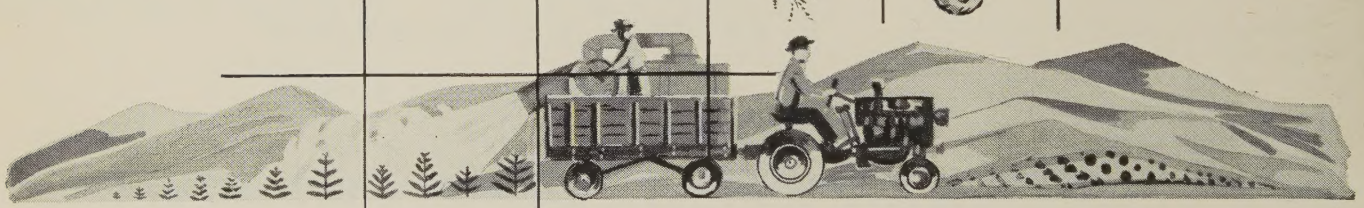


...BUT WHAT A 2% !





A recently compiled breakdown of Sulphur consumption in the United States, shows about 2% of the Sulphur goes into the manufacture of insecticides and fungicides.

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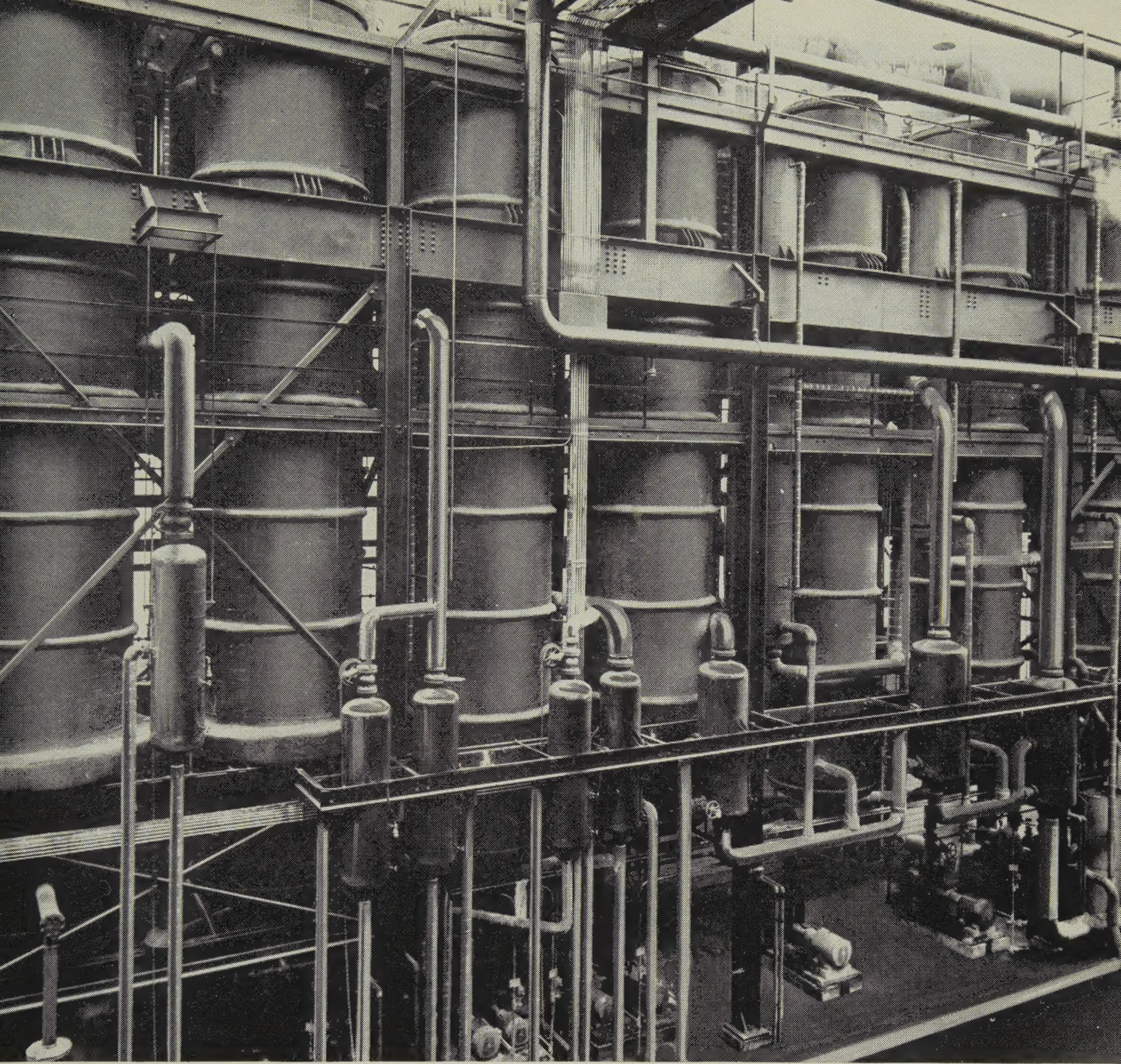

per mill handles waste liquor from 400 tons of pulp per day in a Buflovak Septuple Effect Evaporator. With a total ating surface of 66,500 square feet, this especially designed unit evaporates 6.3 pounds of water per pound of steam.

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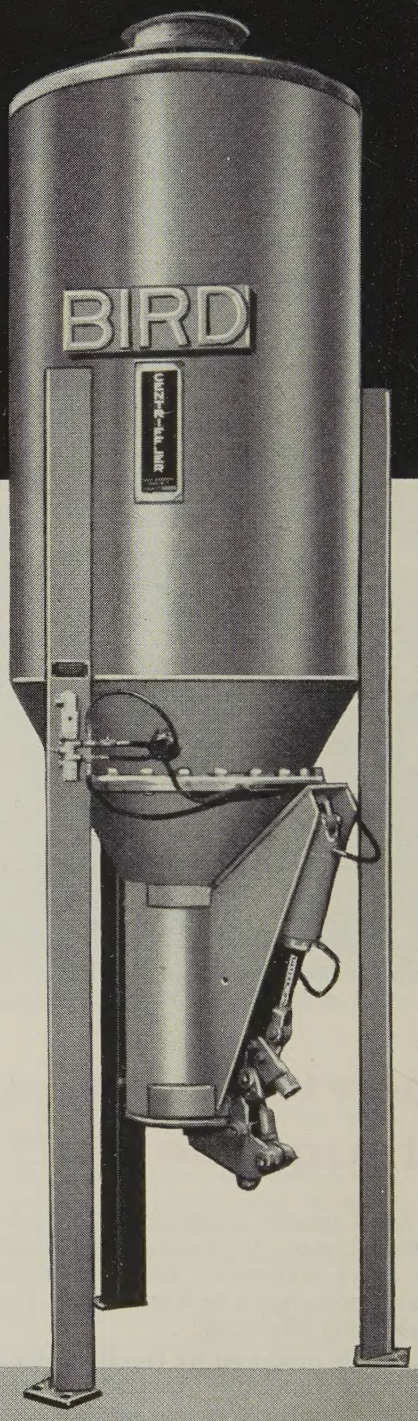

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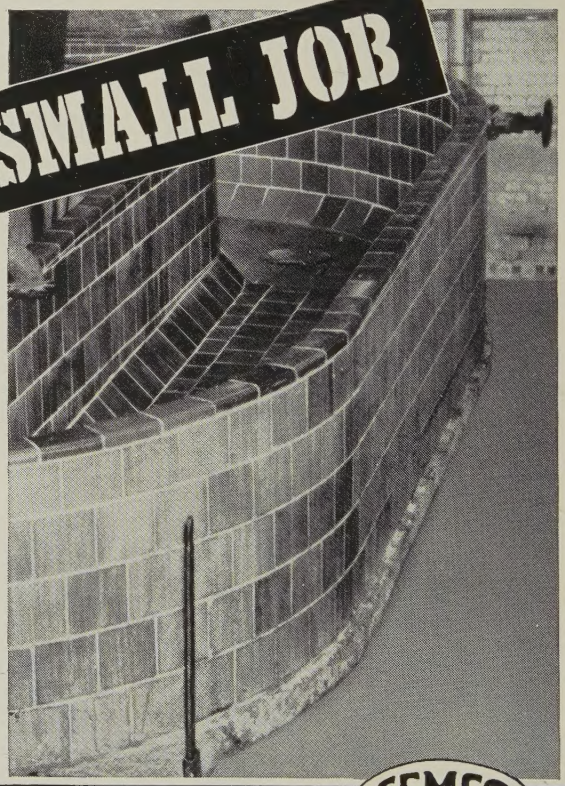
SMALL JOB



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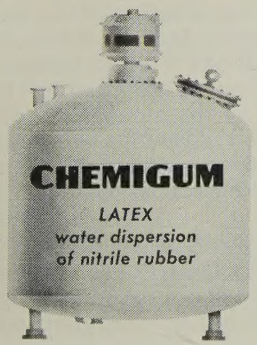

GOODYEAR
CHEMICAL DIVISION

Chemigum—T. M. The Goodyear Tire & Rubber Company, Akron, Ohio

1958 has been a year of healthy consolidation. The generally lower level of new business we have had in common with most capital goods companies has given us a much needed opportunity to examine all our operations with the emphasis on sharpening efficiencies and stepping up the rate of our technological advance. In both, we have made substantial gains.

The sharpening of efficiencies is evidenced by a number of changes. Our manufacturing costs and delivery times are both noticeably better. A reorganization of our Research & Development group has resulted in a greater emphasis on basic research and a speeding up of development of new processes and equipment. This will ultimately include more and better manpower in both these areas. We have simplified routines, eliminated many nonessential operations and projects which seem to creep in during boom times. This allows us to proceed with less staff, but a more able and experienced one.

The current lag in new business has been much less noticeable overseas, and we have been concerned with a number of very large and significant projects abroad. Our subsidiaries have continued to progress and are contributing substantially to the financial balance of our consolidated effort.

PLANT ENGINEERING — The year's major project was the design of a 150 metric ton per day triple superphosphate plant for Mexico. This large contract includes process engineering, plant design, purchase of equipment and supervision of construction of the granular fertilizer plant as well as attendant facilities such as labs, cafeteria, offices and guest house.

A second substantial current project, which is being carried out jointly by D-O and one of our subsidiary companies in Europe, is the design of a large Yugoslavian copper concentrator. Also engineered abroad were a Belgian dicalcium phosphate plant and the expansion of a German phosphoric acid plant. During the year a large fertilizer installation in England went into operation and was rapidly brought up to operating capacity. A fertilizer plant in Montana and a copper concentrator in Israel, both D-O designed, were put into operation late in the year.

Latest addition to the list of installations which the company can now design is the board plant. We are staffed and equipped to engineer any of the basic types including wet or dry process hardboard and particle, insulating, gypsum and flake board.

PULP AND PAPER — A Canadian pulp producer will install a complete D-O Bleach Plant, and Bleach Washers will be utilized in expansion of an Indian groundwood mill. Late in the year Brownstock Washing and Recausticizing Systems, Deckers and hypochlorite preparation equipment were ordered for a new French mill. At a second French mill, a large Brownstock Washing System was put into operation in 1958.

Recausticizing Systems will be installed at two other new mills, one producing paper in India and the other linerboard in the western United States. Continued evidence of widespread acceptance of the American Disc Filter has been demonstrated by the number of orders entered for this efficient saveall. Also of interest were filters ordered for local manufacture from our Australian subsidiary and our Japanese representative.

FOOD PRODUCTS — In the citrus industry, Merco Centrifuges and Mercone Screening Centrifuges have been applied to the finish-processing of orange juice prior to concentration. Successful also has been application of

the Centrifuge-Precoat Filter combination to apple juice processing.

Corn starch washing systems consisting of various combinations of centrifugal equipment were ordered for mills in the United States, Colombia, Holland and Mexico. And, as in so many previous years, the sale of RapiDorr Clarifiers and O-C Filters for cane sugar processing has contributed heavily to orders entered.

FLUOSOLIDS SYSTEMS — Applications of the FluoSolids system were broadened in 1958 to include heat treatment or drying of such materials as foundry sand, phosphate base food products and concentrated detergent and for carbon reactivation. Another new application will be partial roasting of sulfide concentrates at one of Canada's largest smelters.

Other FluoSolids projects now in the design stage or under construction are slag dryers for India and Alabama; pyrite roasters for Spain, South Africa and California; a coal dryer for a midwestern producer and two-stage arseno pyrite roasters for installation in the gold fields of northern Canada. Now in operation or under construction around the free world are over 100 FluoSolids installations on such proven applications as sulfide ore roasting, coal and slag drying, and limestone and phosphate rock calcination.

SANITATION — This phase of our business has been particularly active during 1958 both at home and abroad. Over thirty-five installations of the CompleTreator sewage treatment unit, first introduced last year, are now in operation providing treatment facilities for housing developments, industrial plants, and other small centers of population. Equipment for large domestic projects now under construction include Clariflocculators for a chemical precipitation plant in northern New York State, Densludge Thickeners for the nation's capitol, large Digesters and Distributors for Dallas County, and Clarifiers and Distributors for a Biofiltration plant in Kansas.

Abroad, D-O will supply units for two plants in New Delhi, as well as for installations in Venezuela, Iraq and Kenya. North of the border, extensive additions to the metropolitan Toronto treatment system will be D-O equipped.

Major developments in this field have been the SR Clarifier, a new rapid sludge removal mechanism for final clarification in biological treatment, and the D-O Aerator for the activated sludge process. Installations using both units are already in operation, and a major pulp and paper producer has ordered Aerators for a new waste treatment plant.

COAL — Fine coal recovery and water clarification will be accomplished at Eastern and Australian cleaning plants in large Thickeners ordered within the past year. In a number of instances, an American Filter and ODS Pump will complete the fines recovery circuit.

IRON AND STEEL — Proof of the versatility of the DSM Screen is its application at three points in the heavy media cyclone flowsheet. In its first use on the Iron Range it has considerably reduced magnetite losses. In this general field also the Thickener-Filter combination has continued to be widely applied to recovery of blast furnace flue dust.

CHEMICAL — In 1958 new developments highlighted Dorr-Oliver activity in the far-flung chemical industry. Among the foremost of these was the plastic Filter, a rotary drum vacuum unit constructed of plastic with glass fiber reinforcing. Initial orders indicate the applicability and economy of this unit for mildly corrosive applications.

A second major development, the Merco H-30 Centrifuge, provides the chemical industry with a high capacity, high speed unit capable of clarifying up to 600 gallons of slurry per minute. The product of nearly four years of testing, this machine has substantially reduced operating power requirements per gallon of feed. One of the first commercial applications will be crystal separation at 90° below zero.

Result of yet another new design program is the expanded line of Type L centrifugal pumps. Here, three new designs provide increased capacity and head range and reverse inlet flow for operating speeds of both 1750 and 3500 rpm. In addition, Hypalon elastomer lining is now standard for both Olivite and ODS Pumps.

During the year a German manufacturer ordered the eighth and ninth Horizontal Filters for dewatering artificial resins, and domestic producers purchased Horizontals for such applications as washing ammonium sulfate and nitrocellulose and filtering potash and copperas. Also in the potash field was use of the DSM Screen for debrining crystallizer underflow.

GENERAL METALLURGICAL — Development of an air-lift agitation system for the American Filter has provided a third method of maintaining heavy solids in suspension prior to filtration. Complementing the conventional paddle and swing agitators, this new method has been extensively tested at operating installations.

U. S. and Chilean producers have ordered giant Thickeners with the strongest turntables ever fabricated, and a copper mill in the Belgian Congo will utilize ten large vacuum Filters in a current expansion. New construction at U. S. cement plants includes the three largest Slurry Mixers ever furnished, each 120 feet in diameter, as well as a variety of smaller machines.

WATER — Here also new construction and plant expansions resulted in application of a variety of D-O pretreatment equipment. Two large Hydro-Treator mechanisms will supplement four additional units already in operation at Miami, Florida; and Topeka, Kansas will utilize Presedimentation Clarifiers and Flocculators. PeriFilter systems will be installed at Peoria, Illinois and Leander, Texas; and in Mexico City the first PeriFilter of a new, simplified control design is now going into operation.

Not the least of our gains in efficiency has resulted from new and vastly improved headquarters facilities both here and abroad. Our new International Headquarters was completed here in Stamford in July, the staff of D-O NV expects to move its own new office building in Amsterdam shortly, and our associates in both Brussels and Paris are enjoying new and excellent facilities in co-operatively owned buildings.

In every respect, we are better prepared than ever before to take advantage of the upswing to come and to give better service to our customers throughout the world. This betterment, of course, could only have come about by the diligent and co-operative efforts of our total staff, and to them belongs the credit for the work done.

J. D. Hitch, Jr.
President

November 5, 1958

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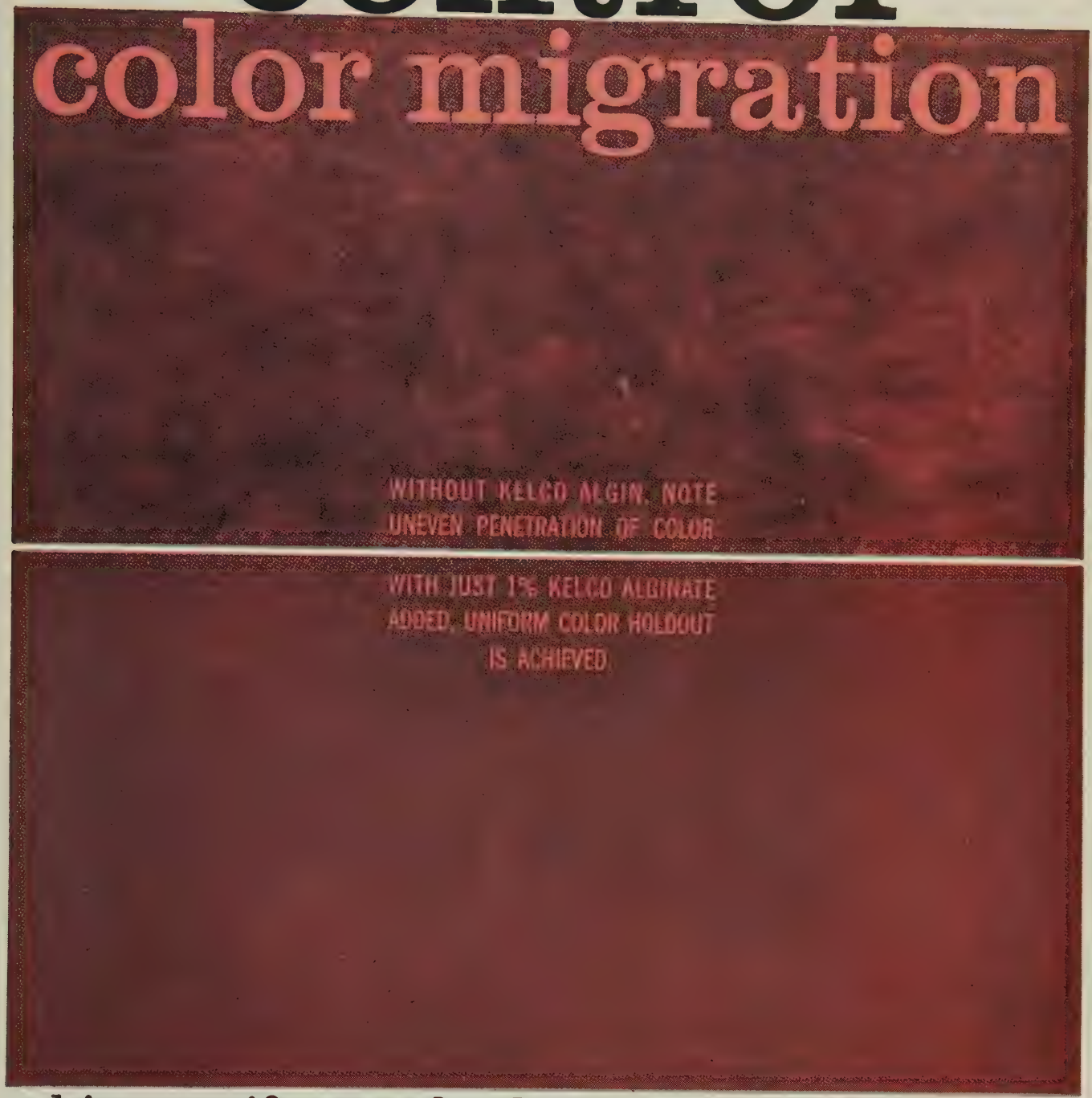

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For the 36th year, the Convention Dailies will do this best of all—because EVERYBODY READS THE DAILIES.

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Trust the leader in the industry to come up with the first and the finest. Cyanamid's vast, diversified and expanding research program is constantly up-grading and improving all Cyanamid products. And our three, fine, new *modified gum* sizes have been developed out of this research. Look them over yourself. They offer new economies in shipping and storage (Cyanamid's 80% solids fortified size is an exclusive in the industry) . . . minimum foam characteristics for top size efficiency (you can make less go farther, or use the same amount for a more highly sized end product) . . . and better color, for highest paper brilliance.

NEW! **ACCOBRITE® ROSIN SIZE 4028**
—Unfortified modified gum rosin size . . . shipped as 80% solids. Has excellent color, low foam. Ideal for use in board . . . and much lower in cost than fortified size. One of the lightest-colored sizes available—and the most efficient!

NEW! **CYFOR® ROSIN SIZE 4016A**
—A top-grade, fully fortified, 70% solids, modified gum size. Its low foam means highest size efficiency . . . and its good color (and competitive price) make it an excellent choice for mills making book, bond, ledger and board.

NEW! **CYFOR® ROSIN SIZE 4029**
—Save on shipping and storage with this exclusive, 80% solids, fortified size! Cyanamid is the only manufacturer making it. What's more, the General Electric Brightness Indicator shows this size to have extra-light color. It contains the same high-quality gum rosin used in 4028!

These three new sizes are just a small part of Cyanamid's great family of sizes. At Cyanamid you'll find more sizes, and more types of sizes, than anywhere else! Count on Cyanamid always for the best possible sizes—at the best possible price. It will pay you to call your Cyanamid Paper Chemicals representative to talk over your size needs. He's equipped to help you with the best knowledge in the industry!

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TAPPI Annual Meeting Program

Commodore Hotel, New York, N. Y., Feb. 23–26, 1959

Forty-Fourth Annual Meeting

The 44th Annual Meeting of the Technical Association of the Pulp and Paper Industry will be held at the Commodore Hotel, New York, N. Y., on Feb. 23–26, 1959.

The following is a tentative technical program for the Annual Meeting and is subject to further change:

Committee Meetings

Sunday, Feb. 22	Afternoon	Coating Council
		Alkaline Pulping
		Engineering Data
		Water Sub I
Monday, Feb. 23	Morning	Wax Sub V
		Fillers and Pigments Testing
		Statistics
		Water Subcommittees
		Empire State Section Officers
		Pulp Purification
		Project 586 Subcommittee
	Luncheon	Pulping, Bleaching and Papermaking Chemicals Testing
	Afternoon	Corrugated Containers Steering and Advisory Councils
		Coating
		Wax Sub I
		Education
		Fourdrinier
		Plastics
		Graphic Arts
		Chemical Methods
		Optical Properties
		Chemical Products
		Bursting Strength Subcommittee
		Plastics Laminates
		Deinking
		Water Subcommittees
		Acid Pulping
		Pulp Testing
		Package Materials Testing
		Converting and Consuming Division Officers
		Semichemical Pulping
		Cylinder Board
		Civil Engineering
Tuesday, Feb. 24	Morning	Wax Sub XIX
		Routine Control Methods
		Container Testing
		Adhesives Testing
		Chemical Methods
		Corrugated Containers Engineering
		Corrugated Containers Production
		Corrugated Containers Industrial Engineering
		Corrugated Containers Raw Materials
		Corrugated Containers Process and Quality Control
		Microscopy
		Forest Biology
		TAPPI-ASTM Task Group for Interlaboratory Evaluation of Test Methods
	Luncheon	Fluid Mechanics
		Chemical Engineering
		Drying
		Mechanical Engineering
	Afternoon	Wax Sub II
		Wax Sub VII
		Precision
		Water
		Adhesives Testing
		Paperboard Testing
		Wet Strength
		Engineering Division SAC
		Dissolving Pulps
		Forest Biology Sub I
		Forest Biology Sub II
		Beater Additives Subcommittee
	Evening	ASTM D 23
Wednesday, Feb. 25	Morning	Wax Sub III
		Wax General
		Agricultural Fibers
		Mechanical Pulping
	Luncheon	Civil Engineering
	Afternoon	Wax Advisory

MONDAY, FEBRUARY 23, 1959

9:00 a.m. Dissolving Pulps Session I (West Ball Room)

1. "The Spinning of Rayon Tire Yarn as Related to Its Structure and Properties," by W. A. Sisson, American Viscose Corp., Marcus Hook, Pa.
2. "Characteristics and Performance of Rayon Tire Cords," by M. W. Wilson, The B. F. Goodrich Co., Akron, Ohio.
3. "Degradation of Cellulose by Ultraviolet Light," by J. H. Flynn, National Bureau of Standards, Washington, D. C.
4. "Outline for a Basic Study of the Differences between Cotton Linter and Wood Pulps," by H. Kraessig and E. J. Howard, Industrial Cellulose Research Ltd., Hawkesbury, Ont., Canada.

9:00 a.m. Forest Biology Session I (South Room)

11:00 a.m. Annual Meeting (East Ball Room)

2:00 p.m. Dissolving Pulps II (West Ball Room)

2:00 p.m. Forest Biology Session II (South Room)

TUESDAY, FEBRUARY 24, 1959

9:00 a.m. Alkaline Pulping Session (Grand Ball Room)

9:00 a.m. Cylinder Board Session I (West Ball Room)

1. "What Is Formation?," by George Sears, Institute of Paper Chemistry, Appleton, Wis.
2. "How Does Furnish Affect Formation?," by L. V. Hoffmann, Container Corporation of America, Wabash, Ind.
3. "Stock Formation versus Good Formation," by George Nicholson, Federal Paperboard Co., Inc., New Haven, Conn.

9:00 a.m. Fluid Mechanics Session (East Ball Room)

1. "Secondary Motions in Flow between Concentric Rotating Cylinders," by David W. Appel, University of Kansas, Lawrence, Kans.
2. "Instability of Flow on the Fourdrinier Wire—Report of TAPPI Project No. 140," by C. S. Yih and A. C. Spengos, University of Michigan, East Lansing, Mich.
3. "Internal Pressure Distributions in Compressible Mats under Fluid Stress," by W. L. Ingmanson, Institute of Paper Chemistry, Appleton, Wis.

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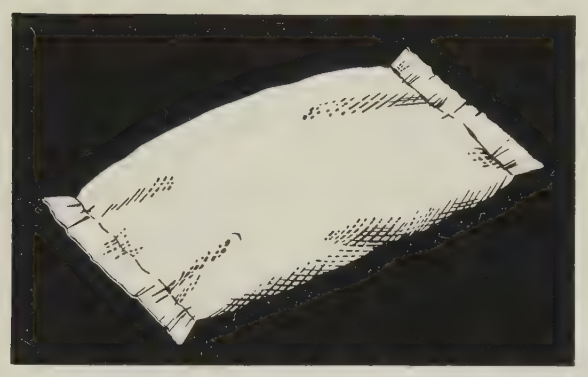

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4. "Secondary Flow Phenomena in Nonlinear Fluids," by J. L. Ericksen, Johns Hopkins University, Baltimore, Md.
5. "The Friction of Paper Stock in Pipes—Summary of TAPPI Research at the University of Maine," by K. J. MacKenzie, Eastman Kodak Co., Rochester, N. Y.

9:00 a.m. Statistics Session I (South Room)

M. S. Renner, W. R. Grace & Co., Dewey and Almy Chemical Div., Cambridge, Mass., *Chairman*

1. "Acceptance Control Charts," by C. H. Chandler, Color Print and Processing, Eastman Kodak Co., Rochester, N. Y.
2. "A General Model for Interlaboratory Evaluation as Applied to the Testing of Paper," by J. Mandel, Testing and Specifications Section, National Bureau of Standards, Washington, D. C.

2:00 p.m. Corrugated Containers Session I (Grand Ball Room)

C. J. Zusi, New England Village, Evanston, Ill., *Chairman*

1. "Quality Control in the Box Shop," by B. Mendlin, Cornell Paperboard Products, Milwaukee, Wis.
2. "Quality Control Inspection from Customer's Viewpoint," by R. T. Holt, Scott Paper Co., Chester, Pa.
3. "Testing Machines Available for Quality Control," by W. F. Bachelder, Testing Machines, Inc., Mineola, L. I., N. Y.
4. "Statistics for Corrugated Quality Control," by G. G. Maltenfort, Container Corp. of America, Chicago, Ill.

2:00 p.m. Fourdrinier Session (East Ball Room)

1. "Experiences in the Use of All-Synthetic Drier Felts," by E. Race, Scapa Dryers Ltd., Blackburn, England.
2. "Paper Machine Guides," by H. Brown, Jr., Appleton Machine Co., Appleton, Wis.
3. "Suction Roll Theories," by C. H. Swartz, Beloit Iron Works, Beloit, Wis.

2:00 p.m. Cylinder Board Session II (West Ball Room)

1. "Effect of Machine Design on Formation," by W. S. Milne, Black-Clawson Co., Watertown, N. Y.
2. "Machine Operation for Formation," by H. Hadley, Diamond Gardner Corp., Gardner Div., Middletown, Ohio.
3. "Need for Uniform Measurement of Formation," by T. S. Brookover, Downingtown Paper Co., Downingtown, Pa.

2:00 p.m. Acid Pulping Session (Room B-C)

1. "Developments in Swedish Sulphite Pulping," by L. Stockman, Swedish Central Research Laboratory, Stockholm, Sweden.
2. "Sulphite Spent Liquor: Separation of Lignin Sulphonates from Sugars in Ion Exchange Resin Columns," by V. F. Felicetta, M. Lung, and J. L. McCarthy, University of Washington, Seattle, Wash.
3. "Operation of the 1957 Experimental Sodium-Base Recovery Plant at Consolidated Water Power & Paper Co.," by R. Q. Boyer and S. R. Parsons, Western Precipitation Corp., Los Angeles, Calif.
4. "Correlation of Vapor-Liquid Equilibria in the Systems SO_2–H_2O–NH_3 and SO_2–H_2O–Na_2) Using an IBM 650 Computing Machine," by H. Gaskill, R. Fleming, V. F. Felicetta, and J. L. McCarthy, University of Washington, Seattle, Wash.

2:00 p.m. Statistics Session II (South Room)

J. Glenn Strieby, Kimberly-Clark Corp., Neenah, Wis., *Chairman*

1. "Evolutionary Operation in Chemical Processes," by J. C. Whitwell, Princeton University, Princeton, N. J.
2. "Example: An Application of Fractional Factorial Designs to a Study of Papermaking Variables," by R. W. Roberts, Marathon Div., American Can Co., Menasha, Wis.

WEDNESDAY, FEBRUARY 25, 1959

9:00 a.m. Corrugated Containers Session II (Grand Ball Room)

H. E. Dunholter, Eastern Box Co., Baltimore, Md., *Chairman*

1. "Operating Experiences on the S&S Die Cut Press," by D. Davis, The Hercules Box Co., Div. of Federal Paper Board Co., Inc., Columbus, Ohio.
2. "A New Design Printer-Slotter," by W. W. Wagner, Jr., Eastern Box Co., Baltimore, Md.
3. "A Revolutionary Concept in the Art of Corrugating Paperboard, the New and the Old Compared," by H. W. Wilson, Royal Container Co., San Francisco, Calif.

9:00 a.m. Graphic Arts Session I (East Ball Room)

J. M. Fetsko, Lehigh University, Bethlehem, Pa., *Chairman*

1. "Reproducibility Studies of Pick Measurements" (Progress Report on TAPPI Research Project 130), by W. D. Schaeffer, J. M. Fetsko, and A. C. Zettlemoyer, Lehigh University, Bethlehem, Pa.
2. "A Study of the Surface Characteristics of Paper and Paperboard as They Relate to Printing Smoothness" (Progress Report of TAPPI Research Project 139), by G. R. Sears and W. A. Wink, Institute of Paper Chemistry, Appleton, Wis.
3. "Photographic Examination of Paper and Paperboard Surfaces to Predict Halftone Printing Quality," by R. O. Ragan, Chicago Carbon Co., Chicago, Ill.
4. "Some of the Factors Affecting the Printing Quality of Newsprint," by R. W. Prince, ANPA Research Laboratories, Easton, Pa.

9:00 a.m. Chemical Methods Session I (West Ball Room)

Joint TAPPI-ASTM-ACS Symposium on Chemical Methods for Testing Cellulose.

1. "New Approaches to Analysis and Testing of Pulp and Paper through Instrumental Techniques," by S. Z. Lewin, New York University, New York, N. Y.
2. "Dry Ashing of Pulp and the Factors Which Influence It," by L. H. Phifer and J. B. Maginnis, American Viscose Corp., Marcus Hook, Pa.
3. "Determination of Starch in Paper," by J. L. Harvey, B. W. Forshee, and D. Fletcher, National Bureau of Standards, Washington, D. C.
4. "Direct Colorimetric Estimation of Xylose in Wood Pulp," by K. A. Kuiken and A. F. Johnson, The Buckeye Cellulose Corp., Memphis, Tenn.

9:00 a.m. Chemical Engineering Session (Room B-C)

1. "Systems Engineering and Operations Research in the Pulp and Paper Industry," by E. F. Thode, Institute of Paper Chemistry, Appleton, Wis.
2. "The Application of an Analog Computer to a Paper Manufacturing Problem," by L. W. Zabel, Kimberly-Clark Corp., Neenah, Wis.
3. "An Operations Research Approach to the Economic Balance in a Kraft Pulping Process," by C. W. Carroll, The Institute of Paper Chemistry, Appleton, Wis.

9:00 a.m. Water Session I (South Room)

J. Patrick, West Virginia Pulp and Paper Co., Luke, Md., *Chairman*

1. "Water Conditioning Trends in the Paper Industry," by C. B. Houser, Cochrane Corp., Philadelphia, Pa.

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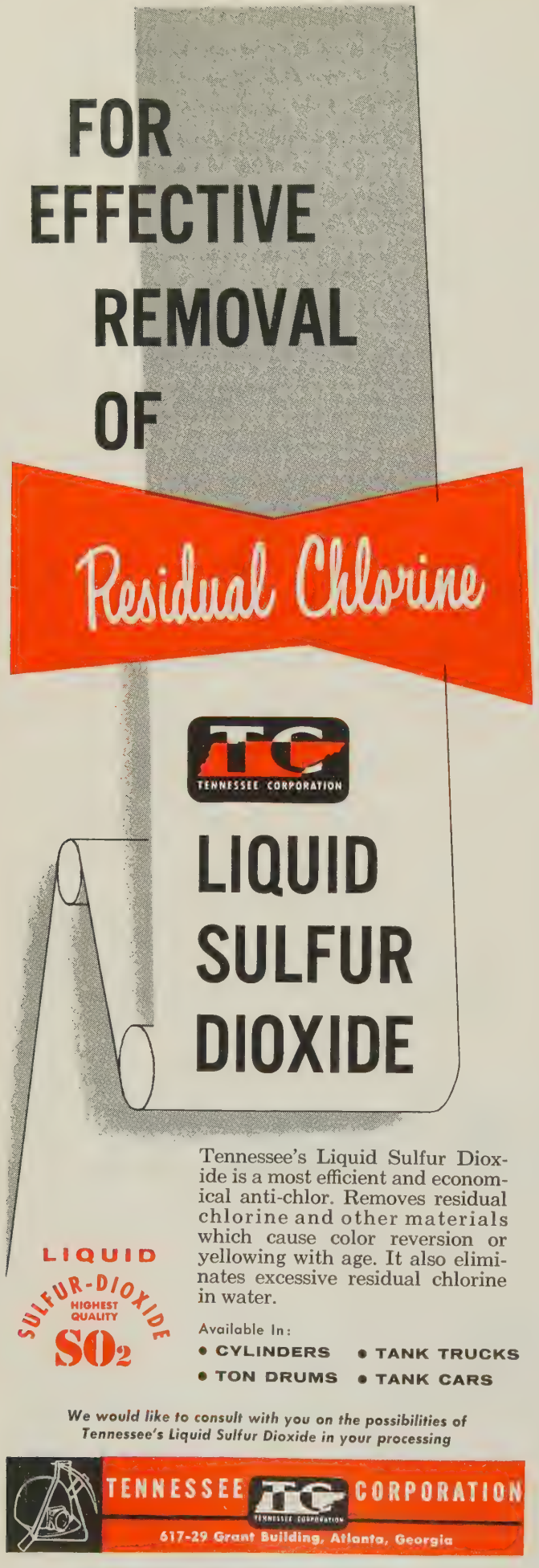
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2:00 p.m. ***General Session I (East Ball Room)***

1. "Phenol for Use in Molded Pulp Products," by Fred Horowitz, and Bayard Carlson, Booty Resineers Div., American Marietta Co., Newark, Ohio.
2. "Adopting the Orphan of the Paper Industry," by C. R. Stevens, Charles R. Stevens, Inc., Maumee, Ohio.
3. "The Effect of pH and Alum Loading on the Activity of Polyacrylamide-Type Flocculants in Papermaking Furnishes," by John L. Date and John M. Shute, Dow Chemical Co., Midland, Mich.
4. "Improved Methods of Testing Remoistenable Gummed Sealing Tape," by C. E. Roberson and W. B. Roberson, Hudson Pulp & Paper Corp., Palatka, Fla.

2:00 p.m. ***Corrugated Containers Session III (Grand Ball Room)***

E. J. Kiddie, Owens-Illinois Paper Products Div., Jacksonville, Fla., *Chairman*

Question-and-Answer Session.

2:00 p.m. ***Chemical Methods Session II (West Ball Room)***

Joint TAPPI-ASTM-ACS Symposium on Chemical Methods for Testing Cellulose.

1. "Progress Report on the Interlaboratory Testing of Pentosan and Carboxyl Methods," by W. K. Wilson, National Bureau of Standards, Washington, D. C.
2. "A Spectroscopic Method for Determining the Lignin Content of High White Pulp Without Hydrolysis of Cellulose," by R. Bartunek, Ver. Glanz. Fab. A.G., Germany.
3. Panel discussion: "Color of Cellulose." Moderator: W. M. Baldwin, Jr., Tennessee Eastman Corp., Kingsport, Tenn.

2:00 p.m. ***Chemical Products Session (Room B-C)***

P. B. Borlew, Celulosa de Chihuahua S.A., Chihuahua, Mexico, *Chairman*

1. "Oxidation of Resin Acids of Pine Chips," by R. V. Lawrence, U. S. Department of Agriculture, Olustee, Fla.
2. "Estimation of Tall Oil in Sulphate Black Liquor," by W. Saltsman and K. A. Kuiken, Buckeye Cellulose Corp., Memphis, Tenn.
3. "Rapid Mixed Indicator Titration Method for the Determination of Rosin Acids in Tall Oil," by E. H. Sheers and L. S. Stevenson, American Cyanamid Co., Stamford, Conn.
4. "Acetic and Formic Acid From Neutral Sulphite Semichemical Black Liquor," by A. Biggs, Sonoco Products Co., Hartsville, S. C.

2:00 p.m. ***Water Session II (South Room)***

E. N. Poor, Hudson Pulp & Paper Corp., Augusta, Me., *Chairman*

1. "Reversible Filtration for Paper Mill Water," by J. G. Brown, Reversible Filtration and Granger Filters, Wakefield, Mass.

THURSDAY, FEBRUARY 26, 1959

9:00 a.m. ***General Pulp Session (Grand Ball Room)***

1. "The Distribution of the Constituents Across the Wall of Unbleached Spruce Sulphite Fibers," by O. Kallmes, Institute of Paper Chemistry, Appleton, Wis.
2. "Sorption Studies of a Modified Locust Bean Gum on a Bleached Sulphite Pulp," by V. A. Russo and E. F. Thode, The Institute of Paper Chemistry, Appleton, Wis.

Failing to get the right unwind equipment can be

A COSTLY MISTAKE

Almost any unwind equipment looks good when it is new, but continuous, dependable performance depends on the brake. Continuous braking required on unwind equipment is one of the toughest jobs in roll processing. When your brake, the heart of unwind equipment, hasn't got what it takes it soon loses control of tension on the unwinding web. Parent roll waste increases and quality goes downhill—fast! By the time you locate the fault you're in real trouble!

Continuous unwind braking is like driving a car on long trips day after day, with the brakes on all the time, all the way. Friction and heat transfer present a tremendous challenge to engineering skill. Unwind brakes don't just hold—they must provide highly sensitive continuous web control through a wide torque range, plus extremely smooth, fast stops. The slightest failure in response can snap the web or set up damaging vibrations.

Play it safe! When you choose your unwind equipment insist that it meet these two important requirements: First, it must be designed specifically to meet the unique demands of continuous service; Second, the unwind brake must be custom-fitted to meet your individual needs as they relate to differences in speed, machine width, roll diameter, tension and characteristics of material.

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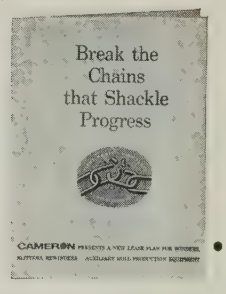
Don't let time and money losses pile up. If you are not getting the *sure* web control you need to stay well ahead of competitive standards then it's high time to contact the Cameron specialists. Do it now . . . write for information on Cameron unwind equipment and web controls.

Ask about the new Cameron Lease Plan



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AA-360

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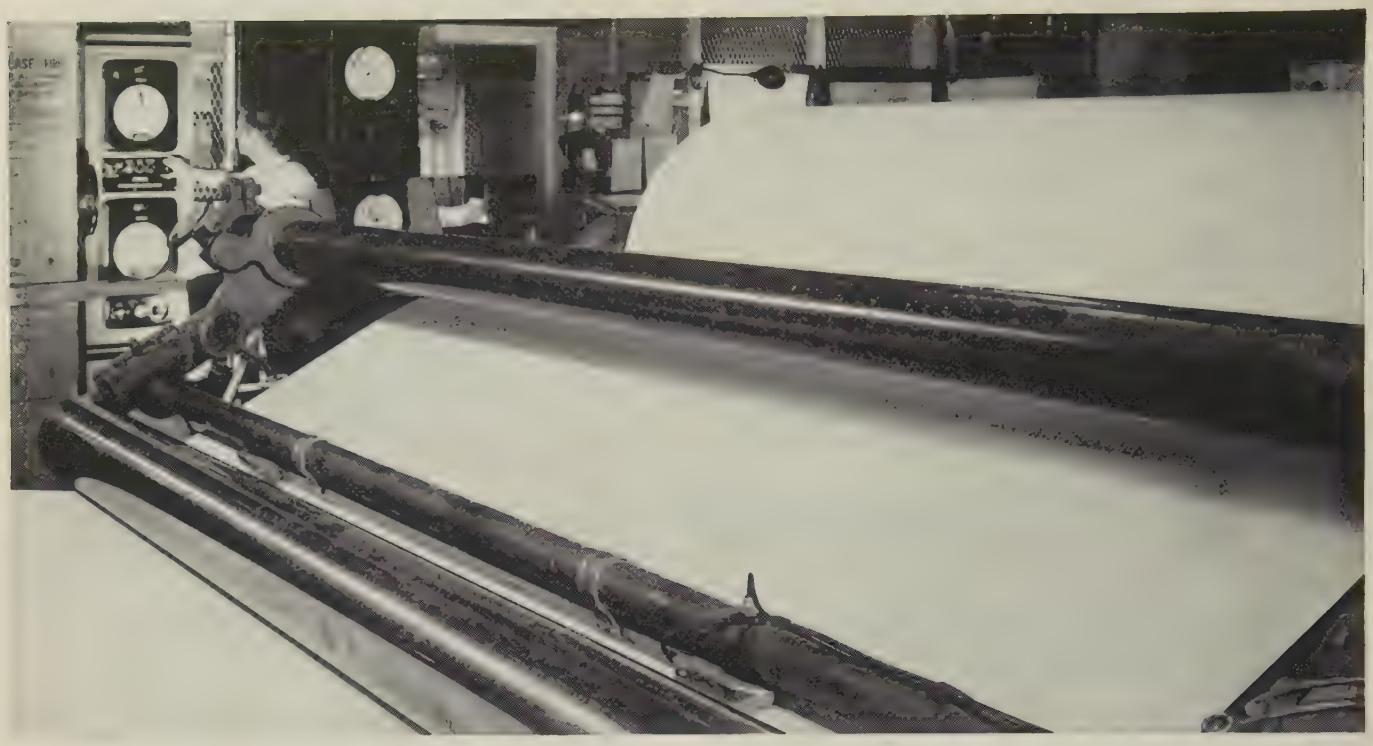

◀ MOISTURE CONTROL SYSTEM on #6 paper machine, Hammermill Paper Company, Erie, Pa. Unique Foxboro sensitive element measures 5 feet across paper — provides wide-span average measurement for fully effective machine control. Foxboro moisture control helps maintain paper uniformity — saves on steam as well.

▼ DIGESTER TEMPERATURES for Kraft Digester at Bowaters Southern Paper Corp., Calhoun, Tenn. are recorded on these Dynalog Electronic Instruments. To insure best possible digester circulation, Dynalogs record temperature measurements from both top and bottom of digesters. Second pen records continuous measurement of digester pressure. Other instruments on panel are Foxboro cam-set Steam Flow Controllers.

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Dynalog design eliminates the slidewire and other moving parts found in conventional electronic recorders. Instead, a simple, variable radio-type capacitor with silent magnetic drive gives stepless continuous balancing. Smooth faster response without waste motion or wear.

For sustained high accuracy and freedom from maintenance, investigate sensitive Dynalog recorders — with fully-automatic pneumatic control action. They can be used for any electrical measurement . . . resistance, voltage, capacity, inductance. Write for Bulletin 20-10 — it gives all the details. **The Foxboro Company, 781 Neponset Ave., Foxboro, Mass.**

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multi-record temperature measurements
density of lime-mud
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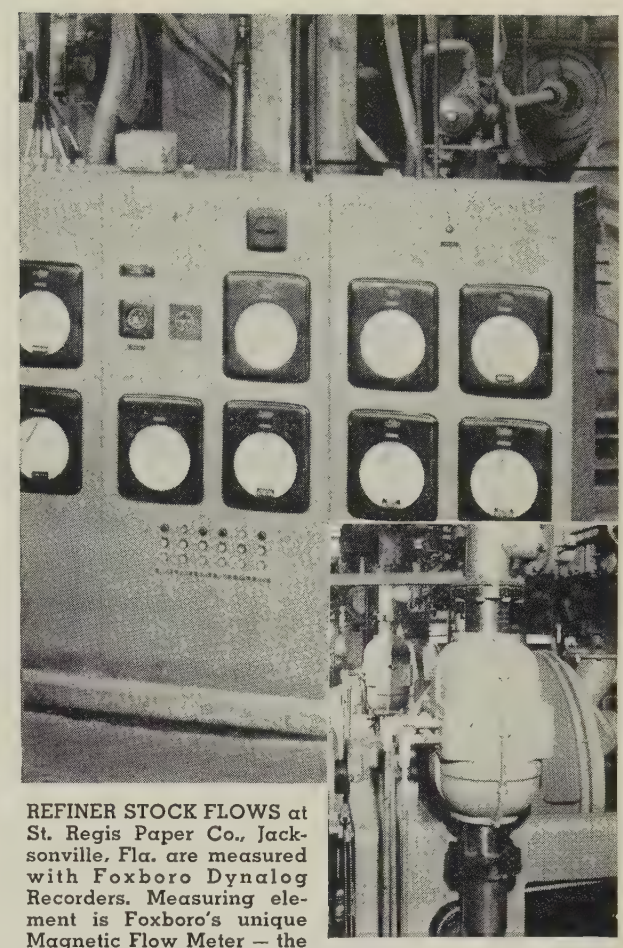
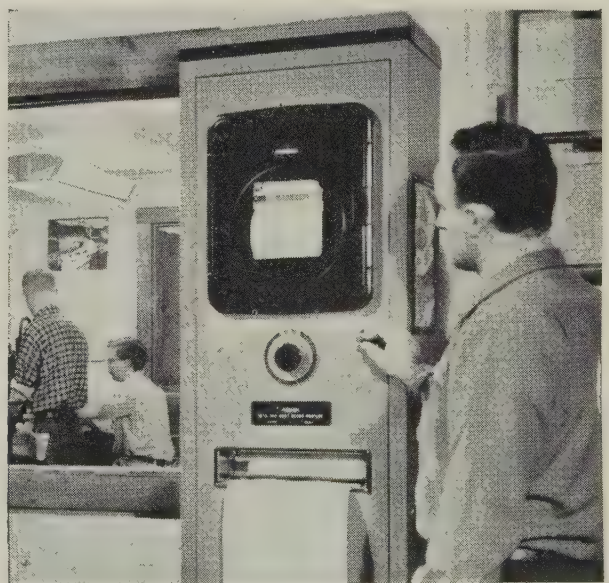


REFINER STOCK FLOWS at St. Regis Paper Co., Jacksonville, Fla. are measured with Foxboro Dynalog Recorders. Measuring element is Foxboro's unique Magnetic Flow Meter — the meter with no flow restrictions. Dynalog instruments also insure proper stock blending to paper machines.



SHEET WEIGHT PROFILER measures and records variations in the basis weight of full-width test samples of paper at American Box Board Co., Filer City, Michigan. Dynalog Strip Chart Recorder provides accurate deviation records all the way across the sheet.

ELECTRONIC INSTRUMENTS

3. "Changes in the Fiber Structure of High Yield Pulps," by R. Marton, State University of New York, Syracuse, N. Y.

9:00 a.m. Mechanical Pulping Session (East Ball Room)

9:00 a.m. Pulp Purification Session (West Ball Room)

1. "Physical Properties of Bleached High Yield Pulp," by N. N. Coe and H. Lance Crosby, Dorr-Oliver, Inc., Stamford, Conn.
2. "The Effect of Pulp History on Pulp Response During Hypochlorite Bleaching," by J. C. Paulson, Buckeye Cellulose Corp., Memphis, Tenn.
3. "Oxidation of Some Simple Organic Compounds with Aqueous Chlorine Dioxide Solutions," by R. A. Somsen, Olin Mathieson Chemical Corp., W. Monroe, La.
4. "Pulp Bleaching with Sodium Chlorate," by H. Rapson, C. B. Anderson, and R. W. Millen, University of Toronto, Toronto, Canada.
5. "Evaluation of Brightness Changes in High Yield Pulps Treated with Sodium Borohydride," by P. Luner, College of Forestry, State University of New York, Syracuse, N. Y.
6. "The Mechanism of the Acidic Chlorination of Lignin," by C. Dence, College of Forestry, State University of N. Y., Syracuse, N. Y.

9:00 a.m. Structural Fibers Materials Session (Room A)

1. "The Measurement of Compressibility as a Factor in Evaluating Experimental Stock Furnishes for Insulation Board Manufacture," by E. J. Reichman, Simpson Timber Co., Seattle, Wash.
2. "Self Heating of Wood Fiber," by K. N. Smith, Johns-Manville Corp., Manville, N. J.
3. "The Evaluation of Fibers for Insulating Board—A New Approach," by J. d'A. Clark, Victoria, B. C., Canada.

9:00 a.m. Microbiology Session (South Room)

G. R. Hunt, National Aluminate Corp., Chicago, Ill., *Chairman*

1. "Microbiology of the Purification of Polluted Waters," by H. Henkelekian, Dept. of Sanitation, Rutgers, The State University, New Brunswick, N. J.
2. "New Technique for Biocide Evaluation," by A. Stern, Research Laboratory, West Virginia Pulp and Paper Co., Covington, Va.
3. "Paper Manufacture under Sterile Conditions," by N. Alper, Chemical Research Laboratories of America, Inc., Lafayette, R. I.
4. "The Cost Efficiency Approach to Slime Control," by S. J. Lederer, Metalsalts Corp., Hawthorne, N. J.

9:00 a.m. General Session II (Room B-C)

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Forecast of 1959 Paper Production

LOUIS T. STEVENSON

We summarize our forecast for the year 1959 and our estimate for 1958 in the following table:

Paper Production

	1000 tons	
	Forecast 1959	*Estimate 1958*
Paper (ex newsprint and building paper)	12,500	11,800
Paperboard (ex building board)	15,400	14,400
Newsprint	1,800	1,700
Building paper and board	3,300	3,000
Total paper production	33,000	30,900

The total for 1958 is substantially the same as the forecast which we published on Dec. 10, 1957, the principal difference being in newsprint.

Figure 1 indicates the growth in the over-all industry, with year-to-year percentage increases or decreases in tonnage indicated by the bars above and below the trend line, beginning with 1946. The last bar on the chart represents our forecast for the year 1959.

The picture shows the reaction of the industry to the business cycle. The lows of 1949, 1952, and 1957 coincide substantially with it. Although the exact low in the latest cycle was in the spring of 1958, the recovery since then has been sufficiently rapid to bring the bar above the line. The 1950 "Korean boom" is clearly shown, as is the 1955 bulge in the 1952–57 cycle. Some of the erratic behavior is due to the fact that it takes about 2 years to bring on stream a new papermaking unit, and this results in a measure of inflexibility in the supply factor.

It is evident that without the step-by-step increases the paper industry could not have attained its present stature. Percentage increases and decreases from each preceding year are shown in the following table:

Table I. Year-to-Year Percentage Change in Total Paper Production

1946....	+11.0	1953....	+8.9
1947....	+8.7	1954....	+1.0
1948....	+3.6	1955....	+12.3
1949....	−7.2	1956....	+4.2
1950....	+20.0	1957....	−2.4
1951....	+6.9	1958....	E+ 0.7
1952....	−6.2	1959....	E+ 6.8

E—Estimated.

OUT OF A RECESSION

The economy of the country reached a low in March or April of this year, and the paper industry bottomed out at about the same time. Since the bulge in 1955, the net percentage increase in paper production shown in Table I has averaged about 1% a year for the 3 years, against a normal 3.9% a year. Furthermore, both 1957 and 1958 productions have been below the long term growth pattern of the over-all industry.

Louis T. Stevenson, Economist, Tucker, Anthony & R. L. Day, New York, N. Y.

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Our forecast is made on the basis that both the economy and the paper industry are in a recovery phase of the business cycle. We expect a good upturn from the recession lows and feel that it is logical that the percentage increase from 1958 to 1959 should be considerably greater than the 3.9% normal rate of growth. The 6.8% over-all increase which we forecast may even turn out to be low in the final results. This rate of recovery has been exceeded six times in the 13 years between 1946 and 1958.

The specific assumptions used in this forecast for the United States economy as a whole in 1959, are (1) that the early part of the year will witness a rising level in the leading economic indicators, and (2) that by fall the Federal Reserve Bank monetary policy, if maintained as at present, should begin to have a retarding effect. On the whole, however, next year should be a year of high volume in manufacturing industries, with moderate inventory rebuilding tending to raise the volume of production slightly above the level of consumption.

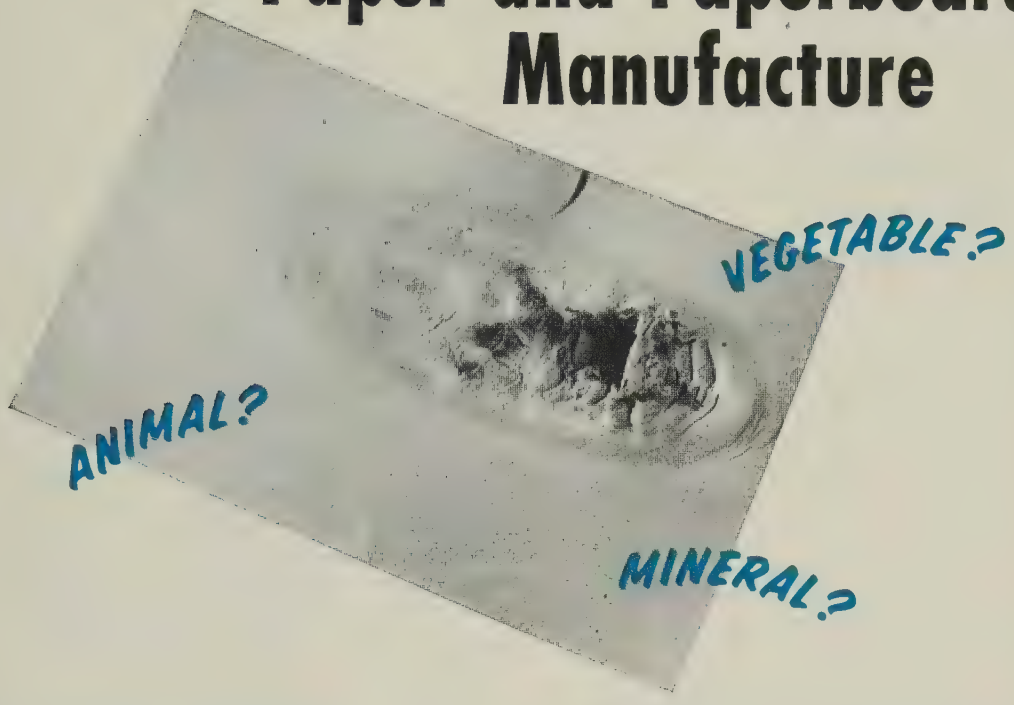
Figure 2 shows our seasonally adjusted monthly indexes of production and demand for two series, namely, paperboard, excluding building board, and paper, excluding newsprint and building paper.

PAPERBOARD FORECAST

It will be noted that there are two major divergences between demand and production of paperboard on the chart. The first in 1955 and 1956 shows production ahead of demand for consumption by a fairly large margin, indicating that inventories were accumulating between the paper mills and the point of consumption. A correction started about the middle of 1956 which, after a temporary upswing in the fall of 1957, reached

Fig. 1

Slimes in Paper and Paperboard Manufacture



PLAYING TWENTY QUESTIONS with the problem of whether slime is animal, vegetable or mineral points up to the fact that in paper mill practice, the word "slime" is no longer restricted to microbiological growths.

To mill men, slimes are any of the slimy deposits which may appear, ranging in content from hydrated fines and true microbiological slimes through hydrated aluminum oxide gels and entrained pitch, iron, silica and calcareous substances.

Identification Critical

Obviously, any appearance of slime in a mill system calls for *positive identification* of its substance, and *action* to bring it under control.

In appearance, it is usually difficult to detect any real difference between slime caused by bacteriological growth and that produced by masses of wet, hydrated stock and inorganic gels. Laboratory analysis is necessary to provide the detailed information required for an expert to recommend the type of control program to be followed.

Variety of Analyses Needed

Nalco Field Service Men have the training and experience needed to deal quickly and effectively with paper mill slimes. They carry test equipment to analyze your system . . . not only for microbiological activity, but also for the many organic and inorganic elements that are part of most deposits. Supplementing their on-the-spot service is the Nalco Paper Process Laboratory, a service and research center equipped for the most exacting analysis work and for comprehensive research on every phase of pulp and paper mill slime control.

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a low in May, 1958. Since then a sharp rise in demand has paced a rapid upswing in production which in turn crossed the demand line in October of this year. During 1958, and allowing for the maintenance of high level paperboard production in the remaining months, inventories of paperboard will have just about stabilized by the end of this year. The year 1959 should start off *without* the inventory accumulation that hung over the market for paperboard at the beginning of the years 1957 and 1958. It seems possible that a further rise in inventories might occur in 1959, although this is not anticipated. The following breakdown of paperboard production is forecast for 1959:

	1000 tons
Container board	8,200
Bending board	3,200
Special food and other bleached board	1,500
Nonbending and other board	2,500
Total paperboard	15,400 tons

PAPER PRODUCTION 1959

In Fig. 2 it will be observed that paper production, excluding newsprint and building paper, has followed about the same course with relation to demand as that of paperboard but with a lag of about 6 months between major movements in which production crosses the demand line. This may be due to the cushioning effect of the relatively large inventories which customarily are held in the channels of distribution. Thus the readjustment from the overproduction which occurred in 1956 and early in 1957, is expected to take longer than for paperboard. It will be noted that the production has rallied sharply from the 1958 low, although it has not crossed the demand line according to the latest data. We expect the demand line to continue at a high level and that production will rise above it early in 1959, and should continue at a fairly high level the rest of the year.

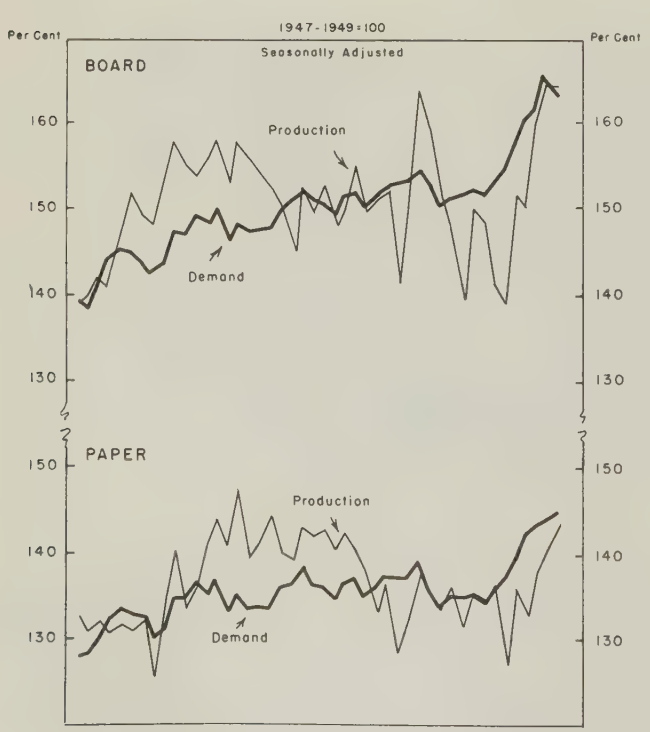

Fig. 2. Paper and board production and demand

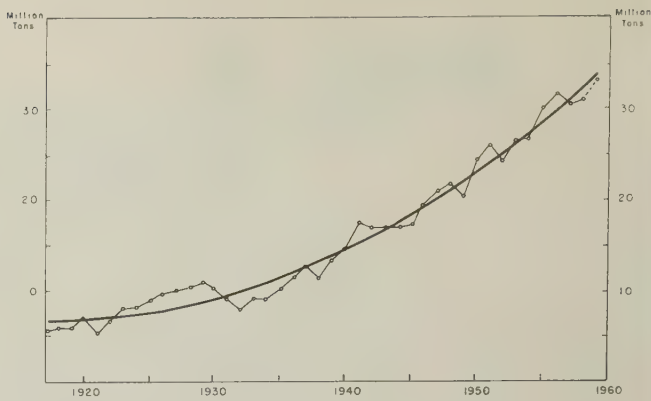

Fig. 3. Trend of total paper and board production

On this basis our forecast for 1959 paper production is:

	1000 tons
Printing paper	4,300
Fine paper	1,600
Coarse and special industrial paper	4,400
Tissue and sanitary paper	2,200
Total paper	12,500

NEWSPRINT

United States newsprint production is only about 25½% of the total consumption in this country. The balance comes from Canada (74%) and a small part (½%) from overseas. The Canadian and United States mills taken together have more capacity than is required by the current rate of consumption. Under these conditions, the competition for business is keen and the proportion of the whole consumption that will be supplied by each of these countries is, to a degree, uncertain. Newspaper advertising lineage plays an important part in determining the volume of newsprint consumed and newspaper advertising fell off sharply early in 1958. A pickup in the last few months is observable and if that strengthens, the United States newsprint mills should benefit. We are accordingly estimating 1959 production of newsprint in this country at 1,800,000 tons.

BUILDING PAPER AND BOARD

There is a close correlation between new construction and building paper and board production after allowing for seasonal factors. We expect new construction to top 1958 and, on this basis, we forecast 1959 production of building paper and board at 3,300,000 tons.

GROWTH PATTERN

Figure 3 shows the over-all production of paper from 1917 through 1958 with a fitted trend line. This shows that the production for both 1957 and 1958 was below the normal growth pattern of the industry as exemplified by the trend line, which has risen 3.9% each year for the 42 years included. During this period the deviations from the trend have been comparatively small, the greatest being just before and after 1932. The fact that 1957 and 1958 production was below trend during the recent recession indicates that, with recovery well started, production volume should swing back to its normal growth line. Although the many increases in the use of paper that will be necessary to bring this about are impossible to evaluate, we feel confident that the long term growth pattern will continue at substantially the same rate. If it should, our 1959 forecast, which is a trifle below trend line, may prove to below.

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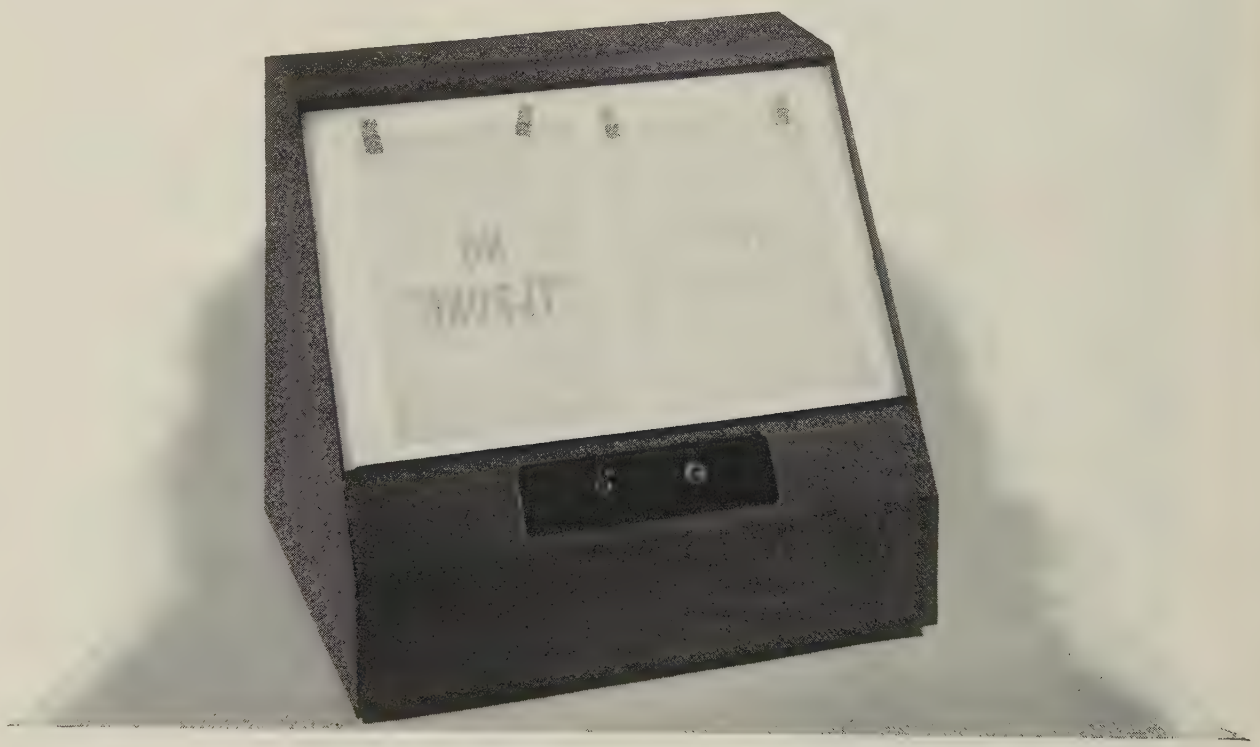

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Research and the Coming World Markets

W. C. PARLE

DURING the months of June and July of this year, I was in Europe to study the changes that are taking place there, which will eventually affect the economy and research of our own country.

Besides this general study and fact finding report, there were six other categories to be handled separately: (1) to determine what my company could sell in this area, (2) what new processes are available, (3) what new products are available, (4) licensing of foreign films with know-how, (5) what savings could be realized in research and development, and (6) what savings are available in raw materials.

A general, over-all picture of what is happening in the European markets, and some thought on how to work with this situation is what I hope to cover here.

The Organization for European Economic Co-operation was established in 1948, and has taken shape slowly since that time. The Common Market, a six-country agreement, comprising Germany, France, Italy, Holland, Belgium, and Luxomberg, consists of an economic cooperation which began on Jan. 1, 1958. Within 10 years, goods between these countries, as well as capital and labor, will have free movement. With trade barriers and tariff barriers between these member countries abolished, uniform tariffs will be established, along with trade policies planned to protect this market against highly competitive imports from the United States and other countries. Still further along these lines is the beginning of a formation of the free trade area which will be comprised of the rest of the European countries in an agreement similar to the one I have just described. At the present time, England and Scandinavia wish to exclude the agricultural products from such an agreement, and this is slowing the formation of such a pact, but, no doubt, it will be accomplished.

The Common Market encompasses a population of some 244 million. Eventually, through economic integration, these Western European nations will comprise the single, most populated and industrial consumer market in the free world—a spending power of over $400 billion, which is about the present United States level. Many American firms, therefore, are studying these conditions in view of putting plants in one of these countries, in order to manufacture their goods in this new economic market. Some of the countries in the market offer very fine opportunities for American firms who are interested in establishing European plants—using European help to produce goods. This is especially true in countries that are strictly agricultural, such as Ireland and Denmark.

The United States chemical industry is the industry that is most vulnerable to this recent development. Besides basic chemicals, even the finished goods derived therefrom, such as pigments and resins, and further on into ink and paints and other coatings, are caught up in these first primary tends: expanding markets in Europe, increasing European competition in the United States market, and mounting European strength in other world markets are a growing threat. In addition, United States participation in European competitive advantages adds to the challenge. The great chemical manufacturing industrial center, of course, is in West Germany, plus some new developments in Northern Italy. Switzerland runs a strong second to Germany in some specialized fields in the chemical industry. Although this market will result in a rise in the standard of living in Europe, it may lower our standard of living considerably as it takes affect. Cheap labor costs in Europe represent one of the most important present competitive advantages of the European firms. The range—from 47¢ to 72¢ per hour, is in appalling contrast to our average manufacturing wage of $2.24 per hour. The European, from my observations, has a high work capacity, and really produces heavily for the time he is on the job.

The European strength in other world markets is ahead of ours. European companies now supply 41% of the world's total export of manufactured goods, while the United States supplies only 15%. They export in the areas that we would not touch—areas known as the "soft currency areas," such as Africa, Asia, Australia, and New Zealand, as well as Latin America, where we are losing position rapidly.

During a 3-week stay in England, I was associated with the fourth largest paint company in the world, and the third largest ink company, and conferred with a very large printing establishment, having over 6000 employees.

My findings in England showed that research was done on a very academic basis, and that the English are extremely thorough with their work. They have compiled a tremendous volume of information on both pigments and resins, and formulations of these materials. Their laboratories are well equipped, especially the laboratories of the companies in the chemical industry. There was, however, one noticeable weakness—that was in the relationship of their research laboratories to sales. The liaison here was very weak in turning research into practical sales items. Here was the first evidence of research being more thorough and complete in detail, perhaps due to the low wages paid to technical men, which enabled them to have a larger staff and accomplish more for the money expended.

I would say the most interesting company, from the standpoint of research, was the German plant of Bayer at Leverkusen, which is within 7 miles of Cologne on the Rhine River. This particular plant, and it is only one of several that belong to Bayer, employed 37,000 people. Fourteen thousand of these people were technicians, chemists, and office clerks.

W. C. PARLE, Technical Director, The California Ink Co., Inc., San Francisco, Calif.

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The Germans possess an immense background of knowledge on pigments and dyes, as well as resins, and are now capitalizing on their past knowledge. Their research work, in general, is set up in a completely different manner than we use in the United States. Their thoroughness is complete, leaving no stone unturned. They do not operate on the *trend system* that is generally used by industrial companies in the United States. The *trend system* consists of evaluating representative members of a class of compounds, and studying general conclusions from the results obtained. Then, based on these conclusions, further study and experimentation is conducted with the subclasses. By contrast, the Germans study every member of a class of compounds, based on trial and elimination.

The German system of education produces thousands of technicians who handle various instruments, and set up chemical equipment as well as any Ph.D. turned out by our universities. These groups of technicians, operating on the incredible (by American standards) wage rate of about 50¢ an hr., are combined into teams of ten to 100 under one or more chemists. These trained chemists, who are known as "Doctors," prepare in detail the work to be done, and later evaluate the work as it is accomplished. On an insecticide project, for example, with 100 technicians and two doctors (chemists, according to our evaluation), 11,000 organic phosphorus compounds under the molecular weight of 1000 had been studied. This realistic educational system operates economically to enable the European to work four to five men on a problem where we would have only one for the same money expended.

Research laboratories in the United States spend from 75¢ to $1.00 for every dollar expended on a project for overhead. This is computed on the basis where all administrative personnel and the complete expense of research are put against every dollar actually spent on a project. The Europeans, however, only spend a fraction of this amount to administer research. This is causing us to miss many important phases of research on a given problem, besides becoming bogged down on actually completing a problem. Steps certainly must be taken to correct this situation or our own economic system will lead us into mediocrity. Americans are noted for their ingenuity and quick thinking in a pinch. This is a fine thing, but in the field of scholarly research, the United States' trend is often toward that of expediency—the fast, stopgap solution. Where research is concerned, genuine basic knowledge is arrived at only by a basic and careful combing of facts. Economically, this may not produce a quick profit for industry, but in the long run, it is the only proper way to gain solid knowledge. Here, I believe, is our real weakness.

I wish to cover some of the new, important items which dovetail in to your industry in converting paper into the final form, in which it is used by the consumer, and acquaint you with some of the detail that is necessary to produce a satisfactory container for some of the packaging done in this country. Probably no one realizes the work done in making the paper, board,

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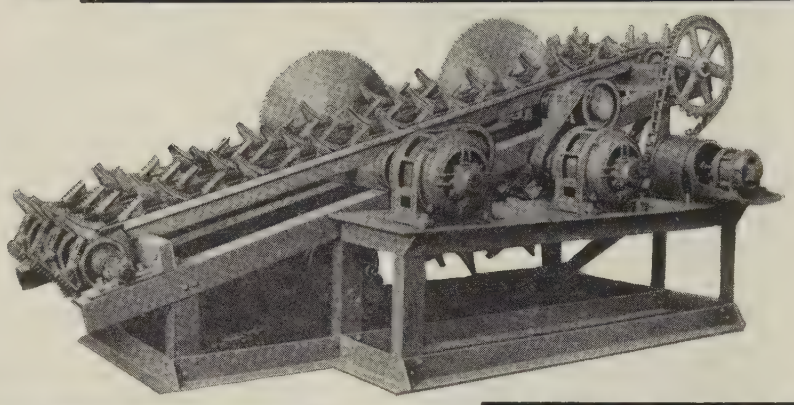

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or ink on these items except the men that actually do the work to produce such a package.

The demands made by the packaging industry for modern day packaging involve many things. When we talk about ink, we talk about color, and color involves pigments and dyes. There has been no basic, important pigment discovery for many years in the United States. It is true that our industrial research in this country has improved the quality of many of the pigments, and mechanically improved the economy of manufacture of many pigments, but, chemically, we have lagged.

Pigment has many different properties that are important to the packaging industry, depending on, of course, what the package is to contain. To find a pigment's usefulness, one is confronted with many physical properties of the pigment: fastness to light, bleed in water, in alcohol, in glycols, in acetone, in ethyl acetate, in aromatic hydrocarbons, in aliphatic hydrocarbons, in plasticizers, in oil, butter, margarine, cheese, paraffin, lactic acid, hydrochloric acid, caustic soda, and temperature.

Much work is being done in Germany and Switzerland on new types of pigments. In Switzerland, a complete plant has been built. In this plant, the manufacture of a new family of pigments has just been started. These pigments show outstanding advantages on the various properties I have mentioned, and will eventually find their way into the packaging industry to be used in quantity. These pigments will not be made in this country for some time, mainly due to economic reasons. Under the present tariff laws, the Europeans can ship these pigments into this country and make a substantial profit, but at a lower cost than we can produce them here.

For the past 15 years, the Europeans have led in the manufacture of various polymers which are suited for coatings. The chemical industry adopted the technology from Europe, and there are now 38 manufacturers of polymeric coating material within the United States. The industry last year produced over 46 million gal. of water-type paint. These materials are composed of acrylic polymers, polyvinyl chloride, polyvinyl acetate, and styrene butadiene. Polyvinyl acetate and polyvinyl chloride were developments of both Germany and England, and were used for coatings in these countries at least 7 years before they were used here. These materials are just now beginning to find their way into printing inks in order to have the advantage of water as a volatile part of the ink. In the next 4 or 5 years, we believe that flexographic ink, both roto and aniline types, will be thrown over, not completely, but greatly, to the water base category. Heat-set ink, both letterpress and offset, has made great strides in Europe, based on new resins developed there in their laboratories, and, again, with greater economy than is possible in this country. In France, I found at least two companies producing high gloss heat set-offset ink that would stay open on the press for hours and yet set immediately on the paper. This ink is made from German raw materials and represents an advance over our products.

The field of elastomers is important in the manufacture and printing of paper and the method of manufacture of the industrial and graphic arts rollers that are used in the paper mills, as well as printing presses. The study of elastomers is a lengthy, detailed study because of the many possible combinations that can be used, and the Europeans are far ahead of us in this work. The study of the urethane reactions originated in Germany, and the first graphic arts rollers made from urethane resins originated in that country. They are now doing further studies with epoxy polysulphides and polysulphide elastomers alone, as well as four other new types of elastomers, to be adapted into the manufacture of various items, among them rollers. These items will represent a great improvement over the present materials used, both in performance and in economy of use in manufacture.

Upon my return, I compiled a 500-page report, containing a great deal of technology, to put my company a step forward in the field of research.

I found the countries visited most friendly, cooperative, and helpful. It is evident that, as far as research is concerned, we are in a very competitive position, and will suffer seriously, due to lack of trained technicians; and our own business economy will be affected greatly when we have to compete in a world market. I would not say that I am completely discouraged by my findings, but I am awakened to what the competition really is in the chemical industry and its allied products and realize that only through a good deal of study would one be able to meet it half way.

Presented at the meeting of the Golden Gate District of the Pacific Section of TAPPI held in San Francisco Calif., Dec. 2, 1958.

Credits: Business statistics from "The European Common Market," Booz, Allen, and Hamilton, International, Ltd.

Smears of size on glass show clarity of Ten-O-Film, right, almost invisible, compared with conventional starch, left.

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The highest degree of coating quality can be achieved with the new, improved Ten-O-Film starches.

These new starches possess unexcelled clarity, uniformity and film-forming properties. They are available in a series of fluidities to meet your exact requirements. Because of their high degree of viscosity stability at high solids, Ten-O-Film starches reduce setback and maintain adhesive strength, assure good performance. At lower concentrations Ten-O-Film starches assure superb structural film continuity and excellent results.

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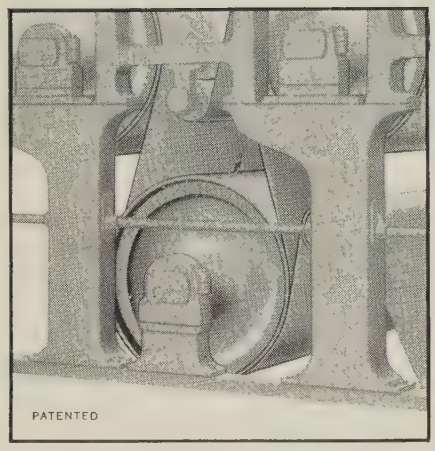
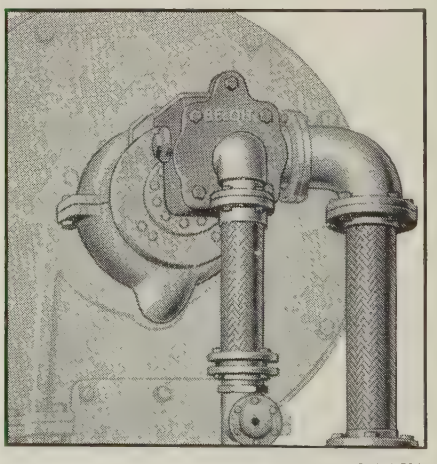


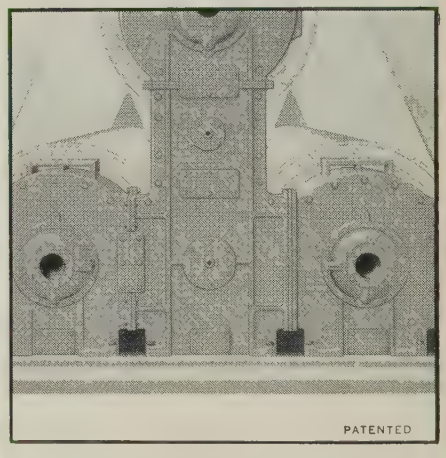
What makes a good dryer?

Experience, sound engineering principles, exacting quality control in the foundry and machine shop—all contribute to superiority. Beloit's advanced foundry and machining techniques bring papermakers a quality product at substantial savings. Beloit dryers are built for long life and trouble-free service. There is nothing that consistently transfers heat or doctors as well as fine cast iron.

Existing steam fits adequate?

Beloit steam fits have been proved in design through years of successful operation. The patented Beloit semi-balanced principle assures minimum wear on carbons and lower horsepower requirements at high steam pressures. Steam fits are a vital factor in efficient paper-machine operation. Rely on Beloit steam fits to give long life and outstanding performance.

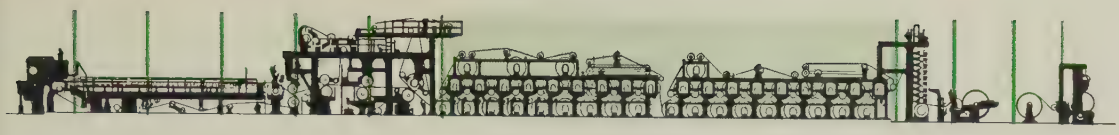




Enclosed gear drive?

It's often a "fine line" of decision whether to keep an open-gear drive or convert to an enclosed gear drive. If your modernization program includes the latter, call on Beloit sales engineers to help plan the installation. Beloit enclosed gear drives offer these advantages: full-pressure lubrication, ease of maintenance, quiet running, safety, and operating cleanliness.

PROVED BELOIT UNITS FOR DRYERS: DRYER FELT ROLLS
SHEAHAN ROPE SYSTEMS WITH AUTOMATIC TENSION CONTROL
POST TYPE FRAMING • SWEAT DRYERS • TEFLON-COATED DRYERS
PAPER TENSION ROLLS • DOCTORS • FELT STRETCHERS



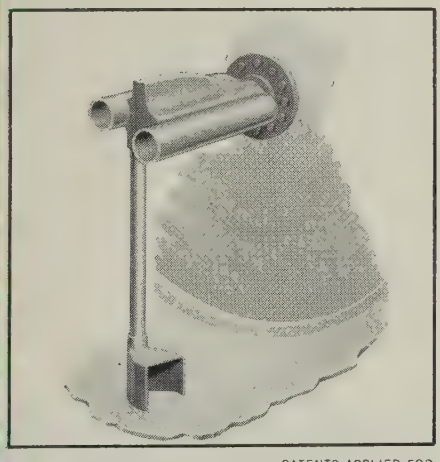
ONE OF A SERIES SHOWING TYPICAL BELOIT SOLUTIONS TO COMMON MILL PROBLEMS

machine's PRODUCTIVE potential?

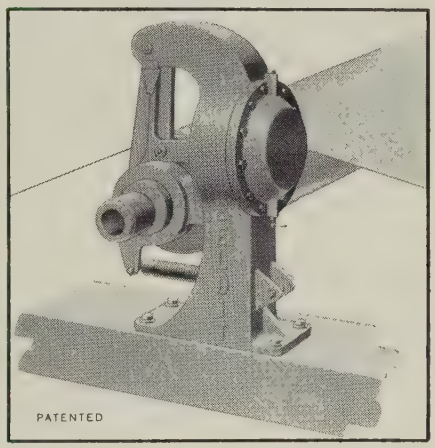
On an otherwise productive machine, allowable steam pressures often are a limiting factor. This usually can be solved without increasing the number of dryers by adding new dry-end dryers with increased steam pressure capacity. If a speed-up is anticipated, existing dryers often can be reconditioned to bring them into balance, and journals re-machined to accept antifriction bearings. Where old journals are not suited for further machining, new heads and journals can be made to fit existing dryers. . . . Below are Beloit components that have proved to be of special value in dryer modernization. See where they fit into *your* modernization plans.

Condensate removal a problem?

Beloit offers several effective solutions to this problem. Beloit's syphons are designed to cover all ranges of operation insuring efficient elimination of condensate. In the majority of cases, kits are now available to convert your present system to a modern Beloit system. Take advantage of this opportunity to bring dryer efficiency up to desired levels.



PATENTS APPLIED FOR



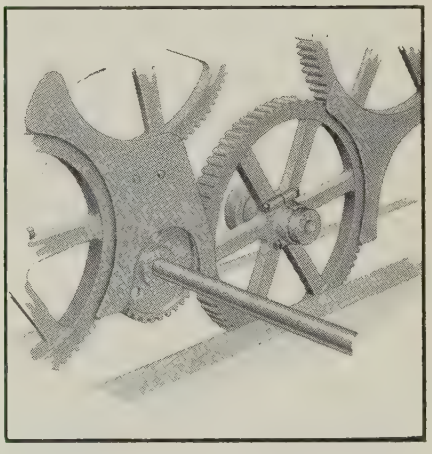
PATENTED

Felts running off periodically?

Faulty felt guides can cut production! Why not modernize with a low-cost Beloit automatic dryer felt guide now? The patented Beloit air diaphragm guide moves the guide roll smoothly, efficiently. Its rate of response is independent of felt speed; outside power supply and floating paddle reduce felt wear. The entire mechanism is simple, foolproof, rugged—requiring a minimum of maintenance. Models available for all dryer felt applications.

Open gears a problem?

If an anticipated speed-up program is being held back by your present open-gear drive, get the facts on Beloit dryer gears. Beloit's finely machined gears allow for that speed-up yet permit operation of an open gear arrangement. Call on Beloit to help work out the best arrangement to fit your particular needs.



» **ACT!** *Write for details —or let a Beloit Sales Engineer help you modernize your Dryer Section. Beloit Iron Works, Beloit, Wis.*

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The Fiber Box Industry—Outlook for 1959 and Review of 1958

THE fiber box industry started 1958 with production at a level below the lowest point since 1954. This was because manufacturers of all commodities were working out of current inventories. However, the picture changed during the last half of the year and not only were inventories being rebuilt but increased commodity sales required more shipping containers. As a result, 1958 fiber box business is expected to be less than 1% below the 1957 volume.

The continued strong demand for shipping containers through the last half of 1958 is expected to be carried over into 1959. With an anticipated increase in the Gross National Product, the fiber box industry should show about a 3% increase in square footage shipped in 1959. There is no indication that inventories in commodity manufacturers' plants have reached their normal levels and there probably will be no slackening of orders for shipping containers. The industry expects 1959 to be the best year since fiber shipping containers were introduced.

Table I. Fiber Box Shipments in Relation to Gross National Product

(Millions of dollars: 1947–49 = 100)

Year	Gross national product		Corrugated and solid fiber box shipment	
	Dollars	Index	Dollars	Index
1947	232,228	93	882	104
1948	257,325	103	869	103
1949	257,301	103	784	93
1950	285,067	115	1055	125
1951	328,232	132	1316	156
1952	345,445	139	1182	140
1953	363,218	146	1317	156
1954	361,167	145	1311	155
1955	391,692	157	1506	178
1956	414,686	167	1601	189
1957	440,000	177	1589	188
1958[a]	435,000	175	1590	188

[a] Estimated.
Source: U. S. Department of Commerce and Fiber Box Association.

TRENDS IN 1958

The fiber shipping container industry manufactures, as its chief products, corrugated and solid fiber boxes, pads, and partitions. However, it also produces displays, expendable pallets, specialty items, products from single-face board, corrugated sheets, and other items.

Corrugated fiberboard, which is the most common type, is usually made from three sheets of paperboard (similar in appearance to ordinary wrapping paper except that it is heavier and thicker). The two outside sheets of paperboard are called the liners and the center sheet is called the corrugated medium. Solid fiber board is made by laminating a number of plies of paperboard together with adhesive material.

The most common type of paperboard used is fourdrinier kraft, and the popular grade has a basis weight of 42 lb. per thousand square feet. The most popular corrugating medium is a semichemical sheet weighing approximately 26 lb. per thousand square feet.

The fiber box industry is of prime importance to the economy. A year's output of fiber boxes sells for over $1.5 billion. In 1958 more than 12 billion boxes were used by business, agriculture, and industry to package practically every type of product made or grown. The railroads of the United States have estimated that more than 90% of all packaged freight they carry is in corrugated boxes.

Many industries automatically grow as population increases, but when the increase is much greater percentagewise than the population growth, it is usually a sign of some significant trend that indicates the industry is becoming relatively more important in the general pattern of economic life. Few industries show more clear-cut evidence of this growth than the fiber box industry. Slightly more than 50 years ago no fiber box industry existed. The industry has grown until there are now more than 400 companies with 700 plants. These plants employ about 50,000 people and their annual payroll amounts to $230 million.

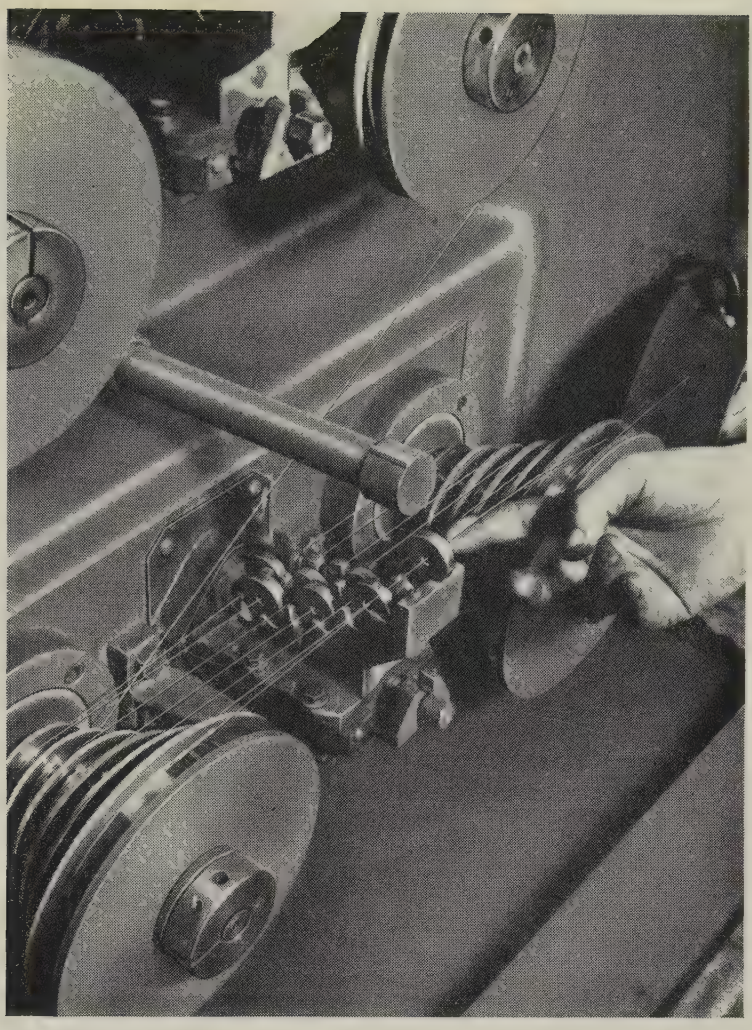
The production of corrugated and solid fiber boxes is one of the key indicators of the state of the nation's economy. The industry is an especially sensitive barometer of the anticipated production of perishable, semidurable, and durable goods. This would include food, clothing, shoes, refrigerators, stoves, etc. In considering the effects which various segments of the economy have on the demand for boxes, it should be realized that almost half of all the corrugated boxes manufactured in the country are used for packing consumer perishable items. Whether the inner container in which the food is packed is a can, a folding carton, or a frozen package, the shipping container almost invariably used is the corrugated box. Since the consumption of food varies almost directly with the growth of the nation's population, a percentage of the corrugated box production varies in the same way.

Table II. Fiber Box Shipments in Relation to Total Industrial Production

(1947–49 = 100)

Year	Total industrial production	Fiber box shipments
1947	100	99
1948	104	101
1949	97	100
1950	112	128
1951	120	126
1952	124	121
1953	134	136
1954	125	135
1955	139	155
1956	143	159
1957	143	158
1958[a]	134	158

[a] Estimated.
Source: Federal Reserve Board and Fiber Box Association.



This is the business end of one of Appleton's 30 drawing machines. Through tungsten carbide and diamond dies, wire is drawn out with micrometric precision . . . to a hairlike fineness. The greater resistance to abrasion and the added strength of Appleton's Fourdrinier wires pay-off in profitable performance on *your* paper machine . . . another reason why Appleton wires are good wires.

Troubled by wire mark in your printing papers? Appleton's *Monoplane* and *Flatwarp* weaves may be your answer. Ask your AWW representative how these special wires can help solve your wire mark problem.

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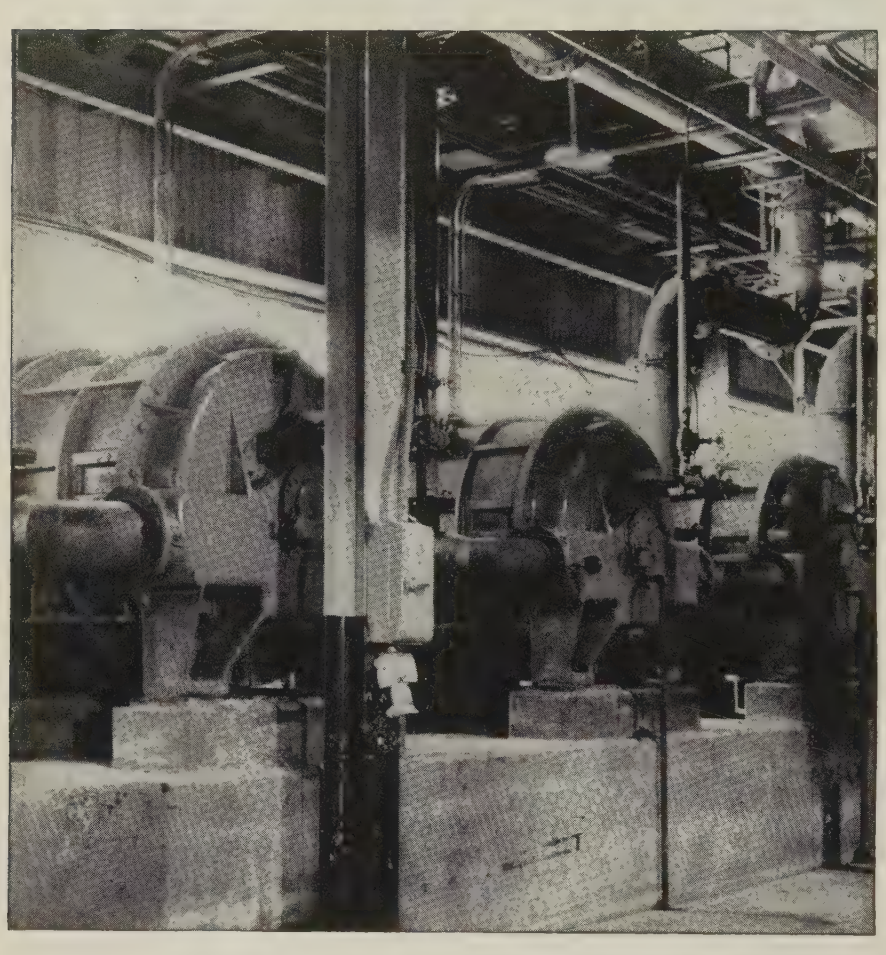
What, actually, do Vacuum Pumps on paper machines handle?



Paper mill engineers know that it is actually a mixture of air and water vapor, but the custom of rating vacuum pumps in terms of air capacity alone causes this important fact to be frequently overlooked.

The presence of this water vapor causes a considerable reduction of the effective air handling capacity of any vacuum pump except the Nash. In the Nash Vacuum Pump the bulk of this water vapor is effectively condensed, due to the Nash operating principle. The air handling capacity of the Nash is therefore not reduced.

That is one of the reasons why Nash Vacuum Pumps are standard in over a thousand leading Paper Mills.

NASH ENGINEERING COMPANY

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Next to foodstuffs, semidurables are the largest outlet for fiber boxes. The decline in consumption of textiles, shoes, clothing, and other semidurables during the first three quarters of 1958 was reflected in a similar downturn in the production of fiber boxes. Although not so important to the box industry as consumer perishable or semidurable items, decreases in the demand for consumer durables such as refrigerators, and stoves and in the demand for construction supplies also lessened the demand for fiber boxes during the first part of 1958. The sharp decline in capital goods production, the lowered employment, and the reduced consumer spending affected all industries, including the manufacture of shipping containers.

Table I illustrates the close relationship of the fiber box industry to the Gross National Product.

The lead time allowed for delivery of fiber boxes is a reflection of the general tenor of industrial operations. When companies are working out of high inventories, the time allowed for a box maker to manufacture and ship his product lengthens. When inventories in the consumer's plants are low, the box maker must deliver on a shortened schedule. In recent months, a change has been noted in the delivery time, and a higher percentage of boxes are being made for quick delivery. This indicates that the country's manufacturing industries are in a stepped up sales and inventory building period.

High production of corrugated and solid fiber boxes in third quarter of 1958 has created a new third quarter high. The fourth quarter of 1958 is expected to be the highest single 3-month period in the industry's history. Because of the current increased tempo, the volume of fiberboard made in 1958 will not fall too far behind the record year of 1956. This is illustrated in Table II, which compares the physical volume of fiber box shipments with the total industrial production of the United States.

Technological advances have helped the industry in 1958, as in previous years. Improved designs and new materials continue to open new markets. The expansion in the use of items such as triple

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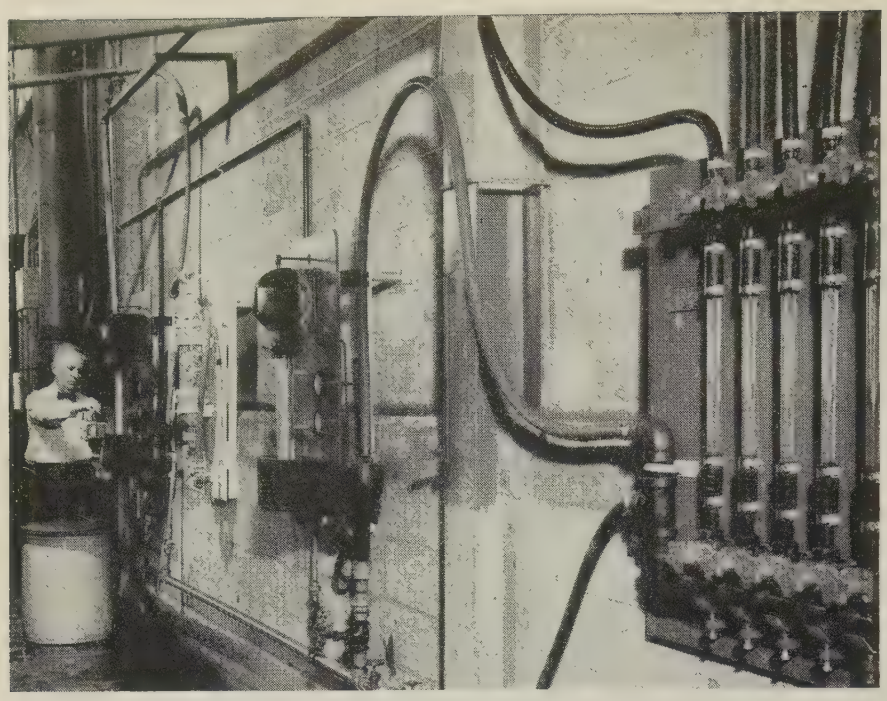

Mr. Albert Jacobs, Plant Supt., inspects W&T Slime Control Equipment at Electric City Paper Mills, Inc., N. Tonawanda, N. Y.

W&T CHLORINATION SYSTEMS

offer complete Slime Control

Electric City Paper Mills, Inc. recently installed new W&T chlorination equipment and eliminated slime in their paper machines. They report, "For years we have been troubled with a very bad slime condition and have spent a considerable amount of money trying to eliminate it. Not until we installed W&T equipment did we realize complete slime control. This has been accomplished at a saving in cost to us of more than 50%. Not only did we save money but we are getting desired results."

Whether you operate a paper or board mill, or a chemical plant, moderately priced W&T Chlorinators like those shown installed at Electric City Paper Mills can control water slimes in your processes. For more information send for Bulletin #I-56.91.

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wall board and combination containers, along with developments in chemical coatings and waxes, all promise increased future usage. It is anticipated by the industry that, both through the improved design of current containers and through the furtherance of the uses of boxes made from triple wall board, advances will continue to be made in the packing of heavy and dense items, products which until now have been beyond the range of corrugated board. Through the use of chemical coatings and waxes, the industry expects to make further inroads into the packing of fresh fruits and vegetables in 1959. Boxes which carry fluids packed in polyethylene bags will, it is expected, be used more and more in the coming years.

Foreign trade has little influence upon the industry. Imports, for example, account for less than $^1/_5$ of 1% of the total volume of box shipments. Similarly, exports currently amount to less than $3 million per year—less than $^1/_3$ of 1% of the total volume of box shipments.

Because empty corrugated boxes are light and have low density, they are relatively expensive to ship for long distances and corrugated box shops are therefore usually located close to industrial areas. Almost every major geographical area has a box shop and no industrial area is without one.

THE 1959 OUTLOOK

Because slight increases in food consumption are anticipated during 1959 and significant increases are forecast in the demand for clothing and shoes, it is expected that the use of corrugated boxes will increase and that 1959 will be the best year in the industry's history.

Issued by the Business and Defense Services Administration, Containers and Packaging Division, United States Department of Commerce, Washington, D. C.

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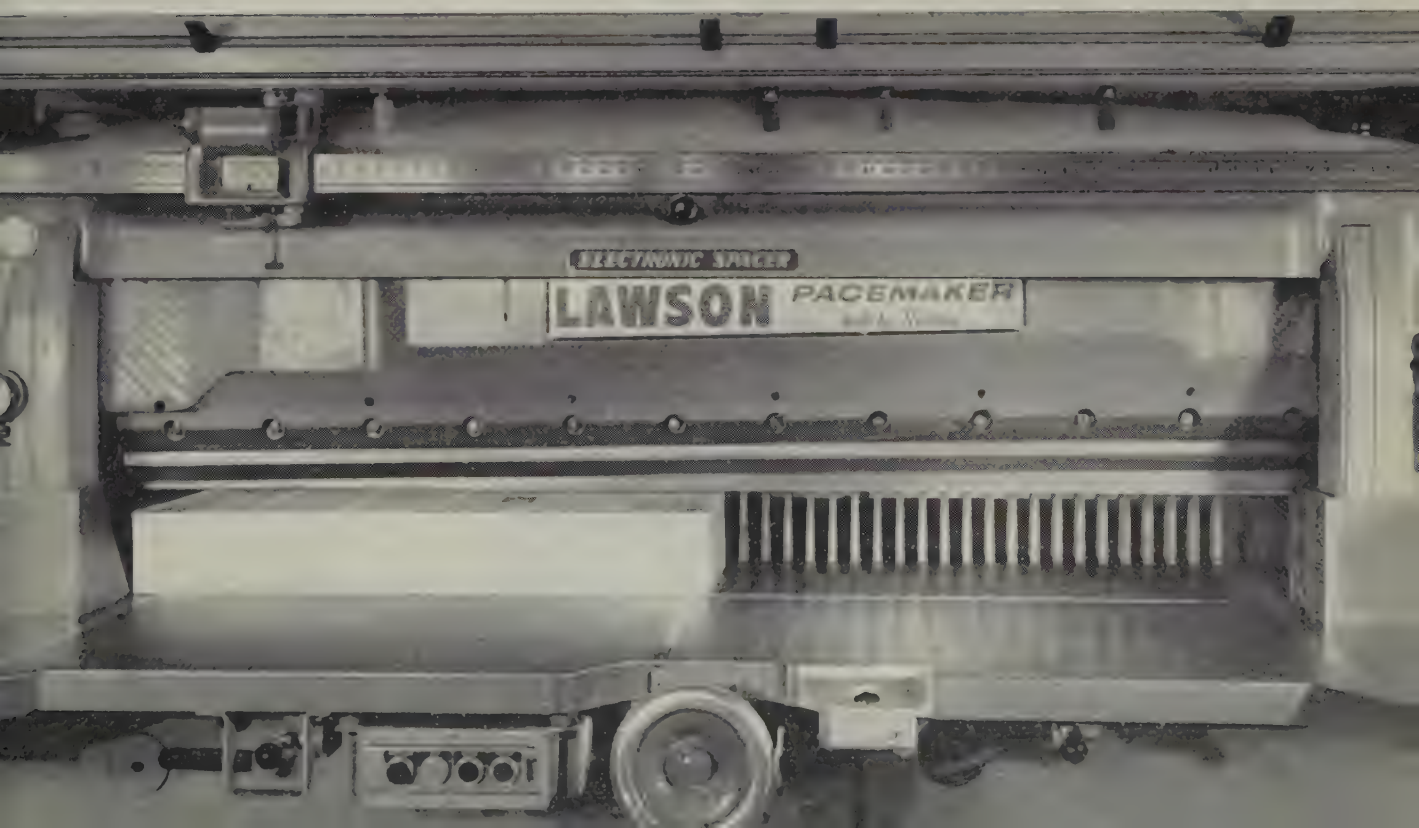

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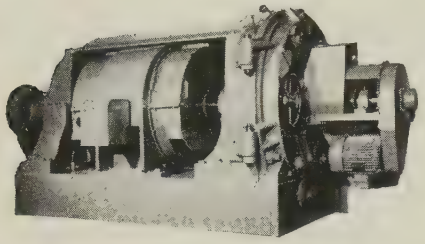


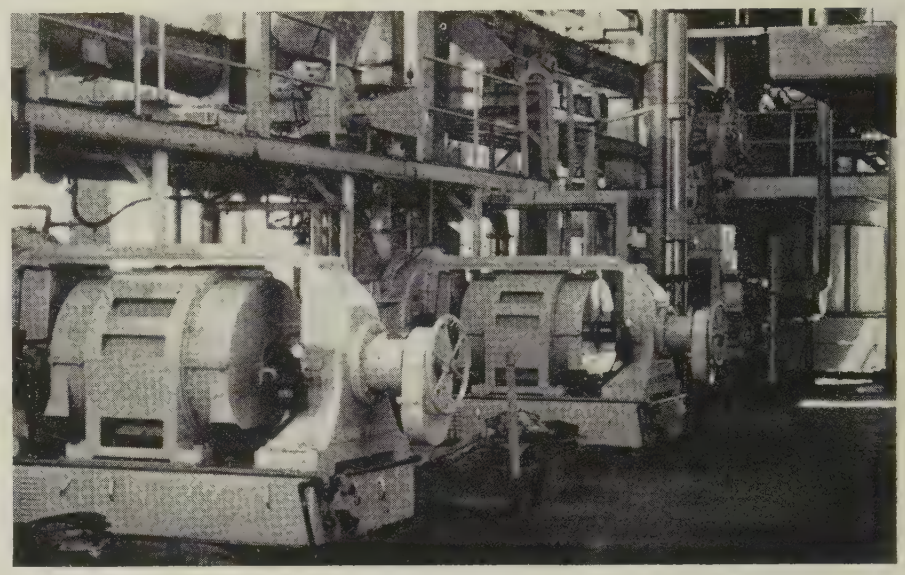
COLD CAUSTIC FOR TISSUES

At the Ninth Congress of the Association Technique de L'Industrie Papetiere held in Strasbourg, France in the spring of 1956, a technical paper was presented describing research studies which indicated the practicability of producing sanitary papers from poplar pulp by means of the cold caustic process.

Just about a year later the first commercial installation was underway at Cartiera Vita Mayer & Company, Milano, Italy. Production of 30 tons per day on a continuous basis was reported.

The logs are debarked, chipped, screened and then brought in contact with the caustic solution. Temperature is maintained at 40°C. Liquor to wood ratio is 16:1 and treatment time is about 10 minutes. Pressing is accomplished in three stages and is followed by refining in precision-built 36-2 single disc "Sprouts."

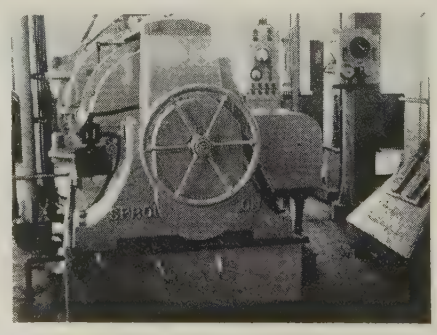
According to Vita Mayer, the cold caustic process offers them simplified control, continuous production, high yield and low cost. **For the full Vita Mayer story, ask for Better Fibers Report No. 26.**



Three Sprout-Waldron single disc refiners helping to produce 50 A. D. Tons/Day of cold caustic furnish for newsprint. Since this picture was taken, three additional "Sprouts" have been installed . . . capacity is now rated at 80 A. D. Tons/Day.

COLD CAUSTIC PULPING FOR NEWSPRINT

Behind the technical story of successful cold caustic pulping, soon to be revealed by Australian Newsprint, is the superb performance of three 36-2 500 hp "Sprouts." Refining of eucalyptus woods for use in newsprint is being accomplished at 50 hp days per O. D. ton. Consistent yields of 90% are being achieved. The CSF is 150.

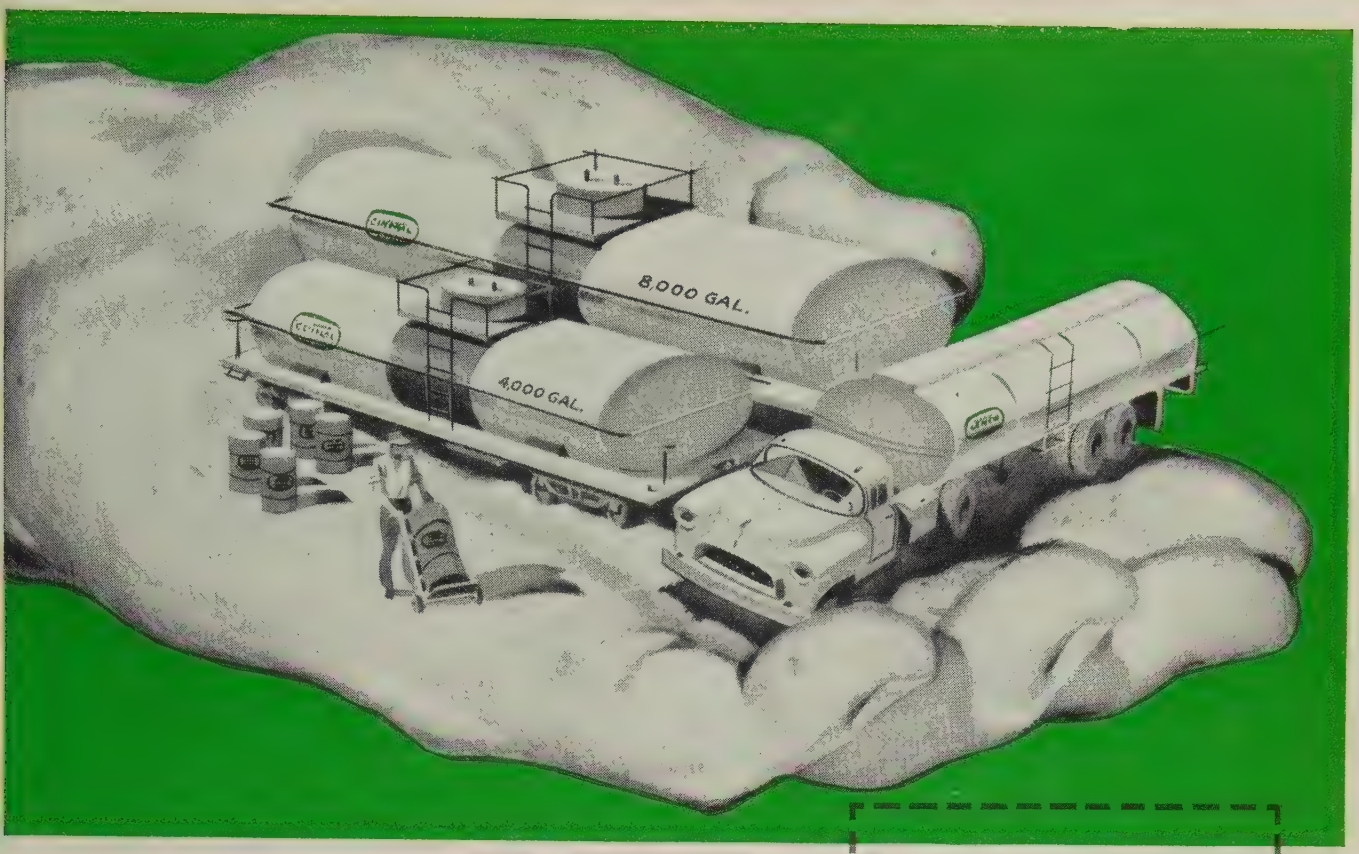


Close-up of 36-2 "Sprout" on-stream at Australian Newsprint

Prior to the installation of the Sprout-Waldron cold caustic process, the furnish for newsprint at this Tasmanian mill was 18% bleached kraft (pine), 82% eucalyptus groundwood. Machine speeds were 1080-1200 ft. per minute. With cold caustic refining, the furnish is 18% bleached kraft, 20% cold caustic and 62% groundwood. Machine speeds have increased by 100 ft. per minute and newsprint strength is equal to the world's best.

For the full story on this and other Sprout-Waldron cold caustic installations, call or write today. Sprout-Waldron experience with cold caustic refining is based on successful installations and actual production. Why not put this experience to work for you without obligation?

PP-105



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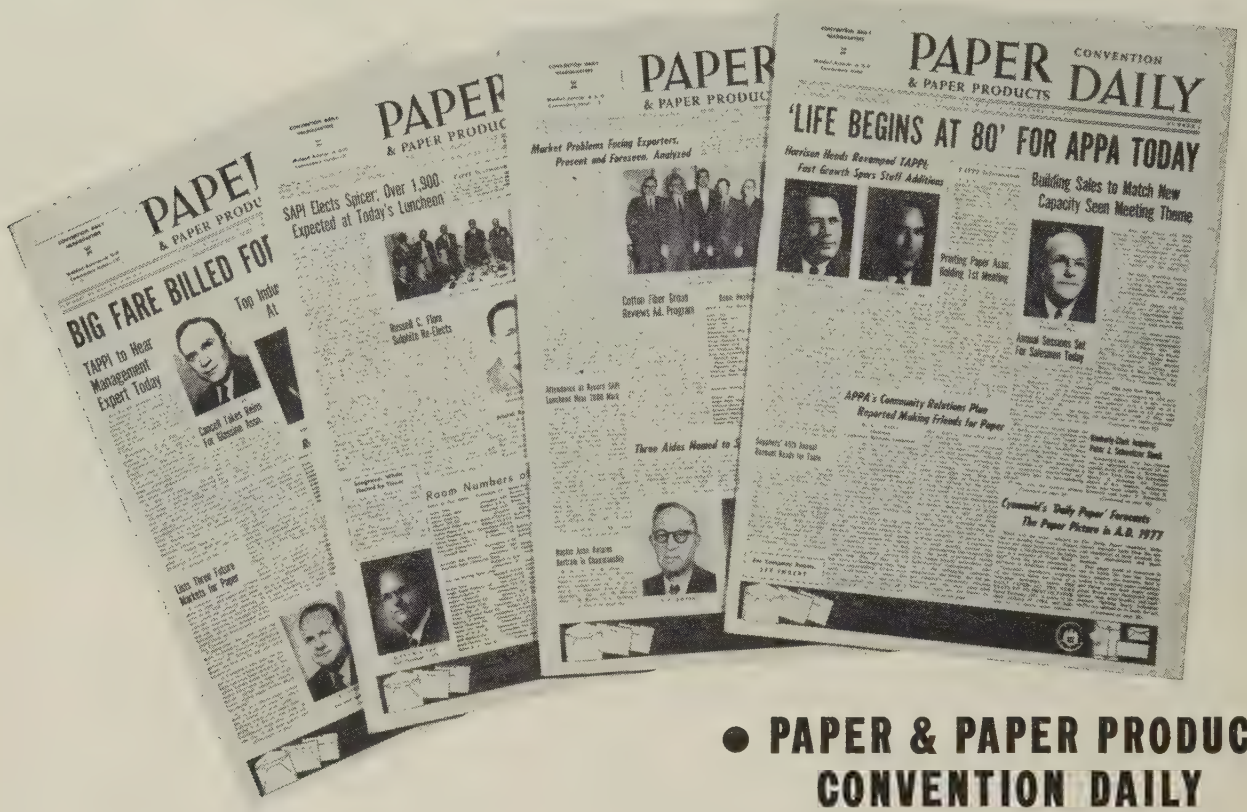
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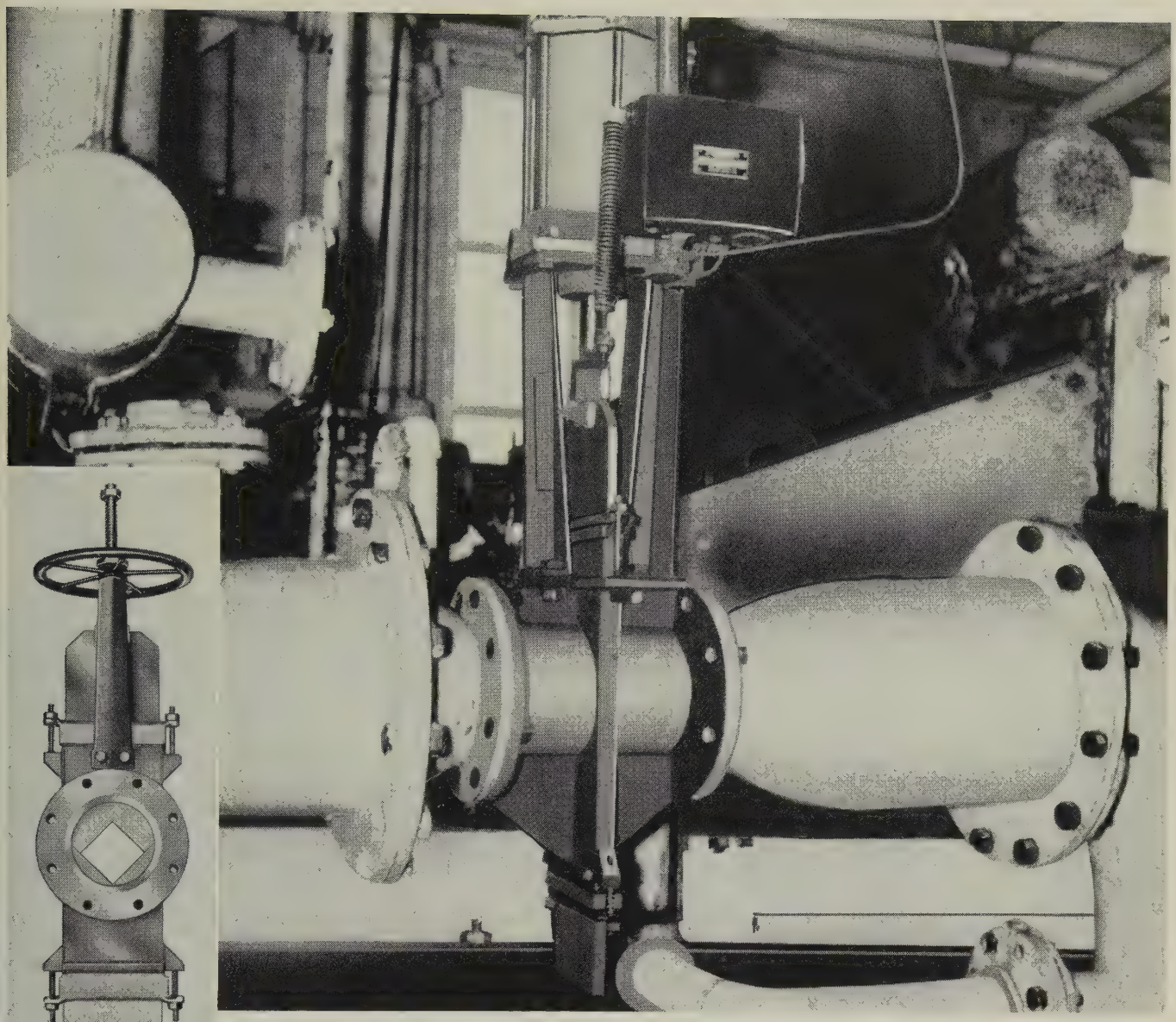

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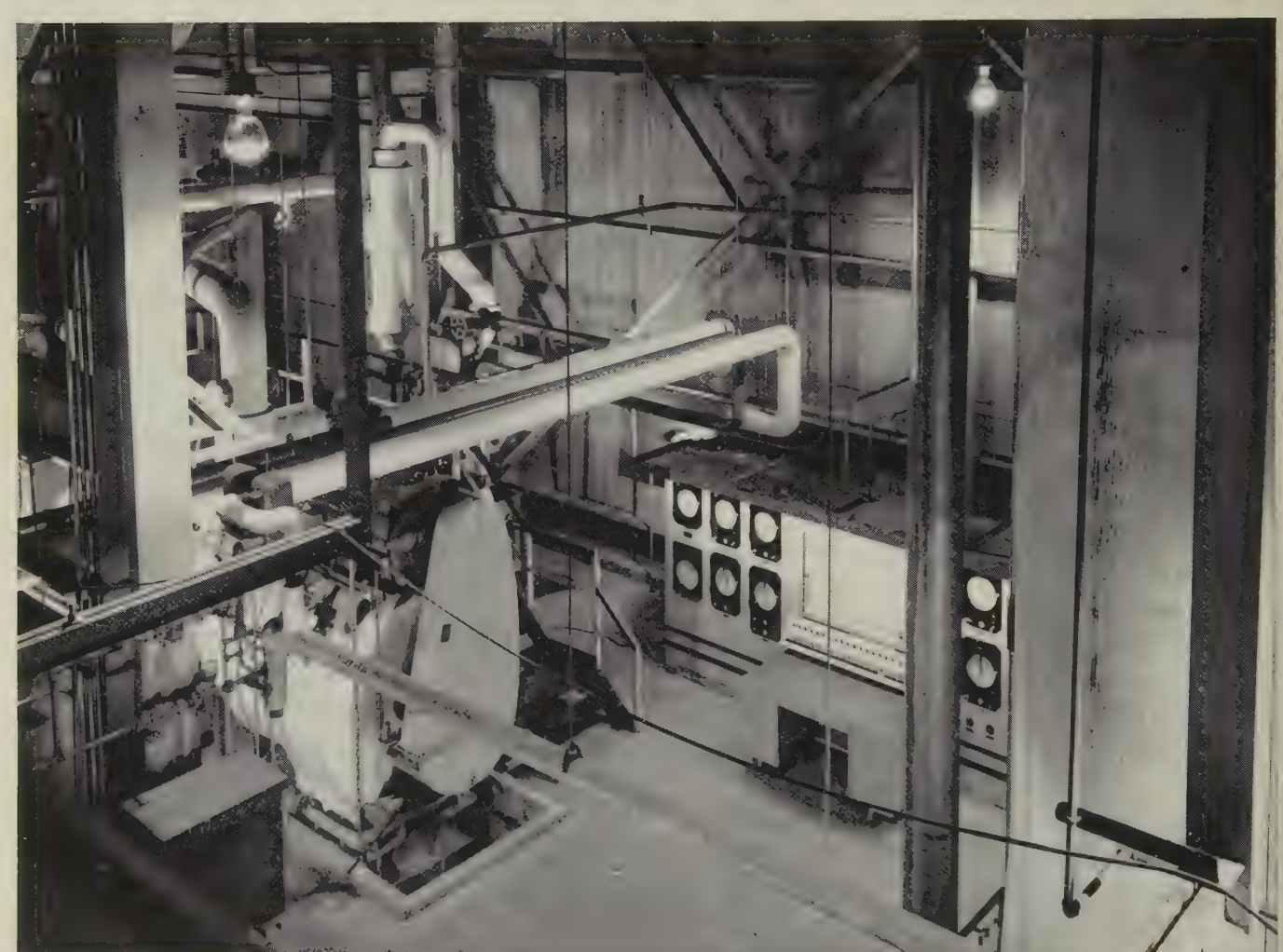
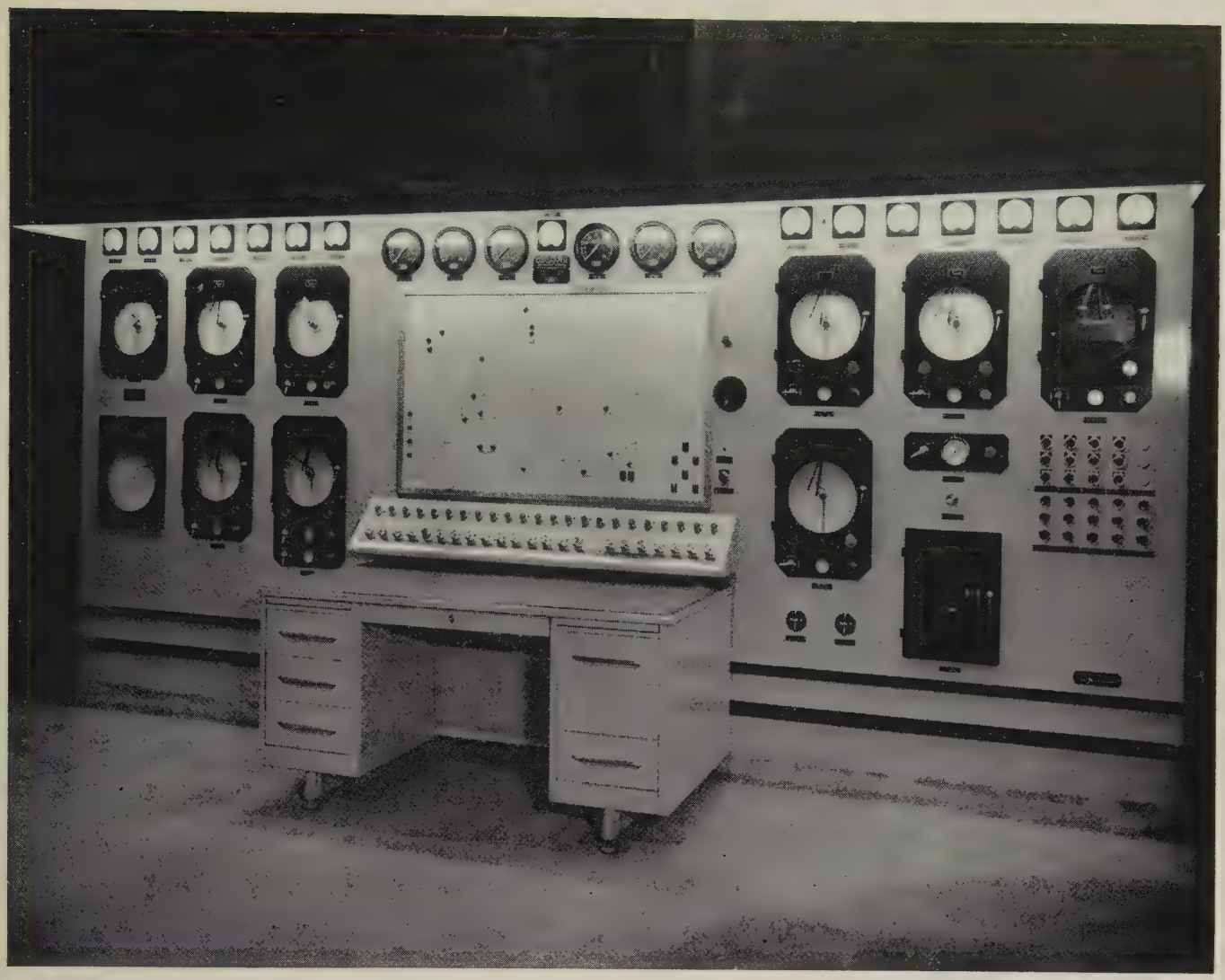


Operating floor of the Lincoln, Maine, Mill, showing convenient location of control panel.

Taylor Instruments



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Name	No. Units	Des. Press.	Steam Temp. °F.	Pounds Dry Solids per 24 Hours
B. C. Forest Products, Ltd.	1	700	550	1,600,000
Canadian Forest Products, Ltd.	1	450	750	500,000
Canadian International Paper Co.	1	300	500	900,000
Chesapeake Corp.*	1	1400	600	1,250,000
Continental Can Co.*	1	975	640	1,120,000
Crossett Paper Mills*	1	1000	700	1,500,000
Dierks Paper Co.	1	675	750	495,000
East Texas Pulp & Paper Co.*	1	700	750	1,600,000
Enso Gutzeit Oy.*	1	1075	900	1,500,000
Enso Gutzeit Oy.*	1	1075	840	1,500,000
Enso Gutzeit Oy.*	1	1400	900	1,500,000
Georgia-Pacific Paper Co.	1	700	750	1,050,000
Halifax Paper Company, Inc.*	1	1000	825	1,500,000
International Paper Co.*	1	1000	825	1,500,000
K. V. P. Co., Ltd.*	1	725	450	1,100,000
Longview Fibre Co.*	1	950	750	2,000,000
MacMillan & Bloedel, Ltd.*	1	690	730	1,020,000
Mead Corp.*	1	1025	850	1,100,000
Nekoosa Edwards Paper Co.*	1	500	700	1,050,000
North Carolina Pulp Company*	1	725	750	1,200,000
Northwestern Pulp & Power, Ltd.	1	700	750	1,400,000
Oxford Paper Co.*	1	800	725	900,000
Rauma-Repola Oy.*	1	1400	900	1,210,000
Rayonier, Inc.*	1	700	760	1,400,000
Riegel Paper Co.*	1	700	725	1,050,000
St. Lawrence Corp., Ltd.	1	700	750	1,060,000
St. Mary's Kraft Corp.*	1	700	725	825,000
St. Regis Paper Co.*	2	700	750	1,150,000
Southland Paper Mills, Inc.*	1	700	750	525,000
Taiwan Pulp & Paper Co.	1	500	825	286,000
Tecnica Cubana, S.A.	1	500	750	240,000
Thurso Pulp & Paper Co.	1	525	710	675,000
Union Bag-Camp Paper Corp.*	1	500	750	1,610,000
Union Bag-Camp Paper Corp.*	1	500	750	1,610,000
United Paper Mills, Ltd.*	1	1075	900	990,000
Weyerhaeuser Timber Co.*	1	700	750	1,050,000

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Top photograph: *Wire of new Southland machine being moved into operating position as it rests on the power-operated undercarriage of Pusey and Jones' Rapi-Drape Wire Changing Device.*

Bottom photograph: *Overall view of new Southland Paper Mills machine.*

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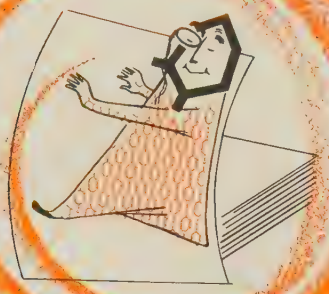

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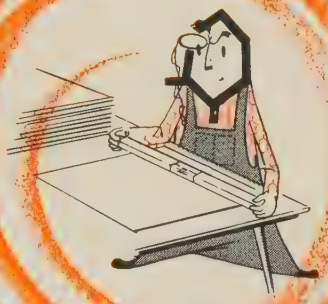

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Progress Report on an Investigation of the Fundamental Factors Determining Coating Color Viscosities

V. F. MATTSON AND J. R. LEIGHTON

Experimental results have indicated that the high shear viscosities of high solids starch-clay coating colors can be interpreted in terms of a theoretically derived viscosity equation. This equation relates the viscosity of a color to the viscosity of the starch, the volume concentration of pigment, the packed sediment volume of the pigment, and a constant which characterizes the color system involved. Some potential applications of the concepts contained in the equation to practical coating problems are mentioned.

Coating colors are complex rheological systems and little fundamental information is available concerning the relationships between color viscosities and the variables involved in color making. In an effort to develop such information, an attempt has been made to interpret coating color viscosities in terms of a generalized theoretical equation for expressing the viscosities of suspensions.

A number of investigators have proposed modifications of Einstein's classical viscosity equation which are applicable to concentrated suspensions (*1–5*). One of these equations derived by Robinson (*1*) relates the viscosity of a suspension of spheres to the viscosity of the suspending medium and to the volume occupied by the suspended particles. By means of measurements made on suspensions of small glass spheres, Robinson demonstrated the validity of this equation for suspensions containing up to 70% by weight of spheres.

An equation of this type could provide a sound basis for both developing a better insight into the fundamental factors determining color properties and for developing less empirical techniques for handling various coating control, formulation, and research problems. The derivation of this equation, however, involves some rather restricting assumptions and the validity of extending it to coating colors has not been established. The specific objective of the present work has been, therefore, to determine whether the Robinson equation can be reliably applied to coating colors.

THEORETICAL CONSIDERATIONS

The derivation of the Robinson equation (*1–2*) is based upon the classical suspension viscosity relationship deduced by Einstein from theoretical considerations. According to Einstein's equation the specific viscosity of an extremely dilute ideal suspension of spheres is directly proportional to the volume concentration of the suspended solid.

Robinson has extended this equation to higher concentrations by introducing the concept that the specific viscosity then will be not only proportional to the volume concentration of particles but that it will also be inversely proportional to the volume of "free liquid" in the suspension. "Free liquid" is that liquid which is not tied up by the suspended particles or by aggregates of particles. It is the liquid which contributes to the fluidity of a suspension.

The volume of this "free liquid" is represented by the difference between the total volume of the mixture and the effective volume of the particles. Robinson has reasoned that this effective volume is equivalent to the packed sediment volume of the particles. If relative sediment volume is defined as the packed sediment volume of a unit volume of particles, the packed sediment volume of the particles in any suspension will be equivalent to the product of the relative sediment volume and the volume concentration of particles in that suspension.

Applying Robinson's equation to coating colors:

$$N_{sp} = \frac{N - N_0}{N_0} = \frac{kV}{1 - SV}$$

where:

- N_{sp} = specific viscosity of the color.
- N_0 = viscosity of the adhesive in the total water present in the color.
- N = color viscosity.
- V = pigment volume per unit volume of color.
- S = a constant which is theoretically equivalent to the relative sediment volume of the dispersed pigment.
- k = a constant which is characteristic of a particular suspension system.

This equation may be transposed to the following form:

$$SV + k(V/N_{sp}) = 1$$

As this form of the equation suggests, the validity of applying the equation to a particular suspension system may be checked by experimentally measuring the viscosities of a series of suspensions of varying V values and plotting V/N_{sp} versus V. Compliance with Robinson's equation is demonstrated by a linear relationship in which the intercepts on the V and V/N_{sp} axes are the reciprocals of the two constants S and k.

This investigation has involved determining whether the high shear viscosities of clay-starch colors containing 50 to 65% total solids and 12 to 20% starch (on a total solids basis) can be expressed in terms of the Robinson equation. This has been done by examining the V/N_{sp} versus V relationship for a series of laboratory colors and by comparing S values calculated from high shear viscosity data with S values determined from direct centrifugal measurements of sediment volumes.

EXPERIMENTAL PROCEDURES

Starch Viscosity and Density Determination

The experimental colors considered in this study were

V. F. Mattson and J. R. Leighton, Research Dept., Oxford Paper Co., Rumford, Me.

Table I. Viscosity Data for Experimental Colors

Starch type	*Starch level, %*	*Color solids, %*	*N_0,[a] cp.*	*N, cp.*	*Nsp*	*Vb*	*V/Nsp*
Stayco M	20	60.0	86.0	171.2	0.991	0.276	0.278
		57.5	60.8	120.3	0.886	0.259	0.294
		55.0	48.4	87.2	0.802	0.243	0.304
	18	62.5	86.0	197.4	1.295	0.303	0.234
		60.0	63.0	135.7	1.154	0.285	0.247
		57.5	47.7	97.0	1.034	0.267	0.259
		55.0	37.5	70.9	0.891	0.251	0.282
	16	65.0	83.6	236.0	1.823	0.331	0.182
		62.5	60.8	157.3	1.587	0.312	0.197
		60.0	46.0	104.9	1.280	0.294	0.229
		57.5	36.0	77.1	1.142	0.276	0.241
		55.0	27.7	54.9	0.982	0.259	0.263
	14	65.0	56.3	180.4	2.204	0.342	0.155
		62.5	43.2	125.0	1.894	0.322	0.170
		60.0	33.1	86.8	1.622	0.303	0.187
		57.5	25.7	61.7	1.401	0.284	0.203
		55.0	19.8	43.6	1.202	0.266	0.222
	12	65.0	38.7	160.4	3.145	0.353	0.112
		62.5	29.5	101.2	2.442	0.331	0.136
		60.0	22.5	72.5	2.222	0.312	0.140
		57.5	17.3	49.6	1.867	0.293	0.158
		55.0	13.8	35.8	1.594	0.274	0.172
Stayco G	16	60.0	90.2	158.9	0.762	0.293	0.384
		55.0	52.0	81.8	0.573	0.258	0.450
		50.0	31.7	45.2	0.426	0.225	0.528
	14	60.0	63.3	126.5	0.998	0.302	0.302
		55.0	37.5	64.6	0.723	0.265	0.367
		50.0	22.8	35.8	0.570	0.233	0.408
	12	60.0	42.3	101.2	1.392	0.311	0.223
		55.0	25.5	51.4	1.016	0.273	0.269
		50.0	15.0	26.5	0.767	0.238	0.310

[a] N_0 is obtained from Fig. 1 after calculating the concentration of starch based upon the total amount of starch-water mixture in a color.
[b] V is calculated by dividing the volume of clay in a color by the sum of the clay and starch-water volumes. The volume of clay is calculated assuming a density of 2.60. The volume of the starch-water mixture is calculated using the starch-water density obtained from Fig. 2.

prepared using two grades of oxidized starch (Stayco M and Stayco G). In order to calculate the specific viscosities of these colors it was necessary to know the high shear viscosities of pastes of these starches as functions of solids contents. In order to calculate the pigment volume concentrations it was necessary to know the densities of these starch pastes as functions of solids contents.

Twenty Stayco M pastes at various solids contents between 8 and 30% were prepared by cooking the starch suspensions for 10 min. at 87.5 to 93°C. The cooks were conducted in 1-l. stainless steel beakers provided with adequate agitation. The solids contents of the cooked pastes were determined by a standardized procedure which involved drying for 12 min. in a circulating oven at 175°C.

The high shear viscosities of these pastes were measured on a Hercules Hi-Shear viscometer. Measurements were made at 50°C. and the apparent viscosities at 1000 r.p.m. were calculated in the conventional manner (*6*).

The densities of several of the cooked Stayco M pastes were measured at 50°C. using pycnometers.

Similar viscosity and density measurements were made for Stayco G pastes. Viscosity data for the two starches are given in Fig. 1 and the density data in Fig. 2. Similar densities were found for both starches at a given solids level.

Coating Color Preparation

The laboratory coating colors were prepared using portions of KCS clay slips. High solids (75%) slips were prepared by making-down clay for 1 hr. with 0.3% Calgon and 0.12% NaOH in a 5-gal. laboratory kneader. Small portions of the clay slip and sufficient water to reduce the solids to approximately 72 to 73% were ball milled in a 1-qt. laboratory jar mill for 30 min.

Starches for the colors were prepared by cooking Stayco M or Stayco G starch at 25 to 35% solids using the procedures previously described.

Coating colors were prepared by weighing the required amounts of clay slip, cooked starch, and water into the

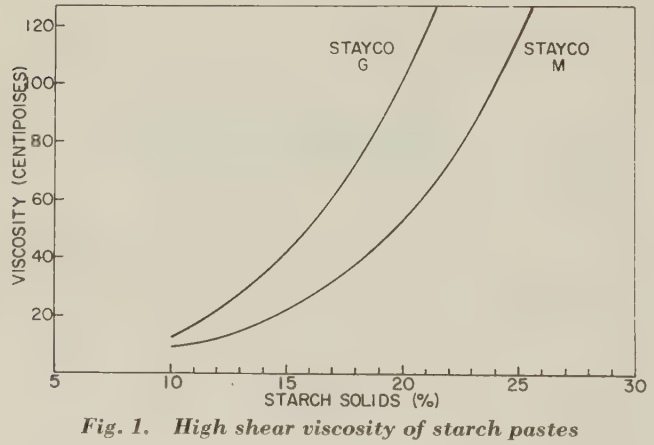

Fig. 1. High shear viscosity of starch pastes

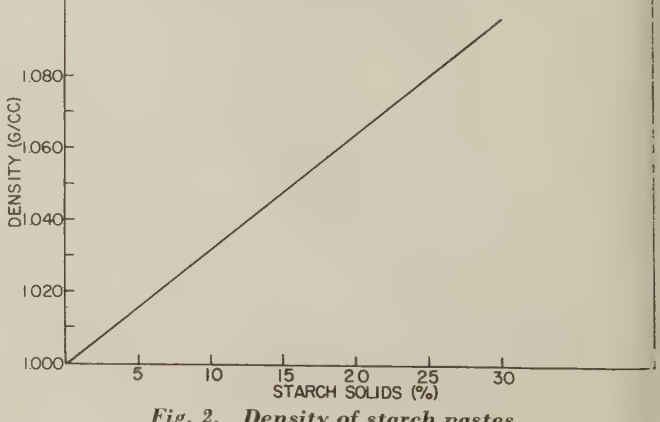

Fig. 2. Density of starch pastes

Table II. Relative Sediment Volume Measurements
(Stayco M-KCS colors)

Starch level, %	*Relative sediment volumes, %, color solids* 20	30
10	1.88	1.90
12	1.88	1.82
14	1.88	1.87
16	1.94	1.83
18	1.98	2.08
20	1.96	1.85

1-qt. jar mill and ball milling for 30 min. The viscosities of the colors were measured on the Hercules Hi-Shear viscometer at a color temperature of 50°C. Apparent viscosities were calculated at a rate of shear of 1000 r.p.m.

Relative Sediment Volume Measurements

The relative sediment volumes were measured by centrifuging weighed portions of clay slips or low solids (20 to 30%) colors in 40-cc. graduated centrifuge tubes until constant sediment volumes were obtained. The relative sediment volumes (RSV) were then calculated according to the equation:

RSV = Sediment volume/(dry clay weight/clay density).

EXPERIMENTAL EXAMINATION OF EQUATION

Applicability to Coating Colors

Twenty-two laboratory coating colors were prepared using the KCS clay slip and Stayco M starch. Solids were varied from 55 to 65% and starch levels from 12 to 20% on the total solids. The high shear viscosities of these colors were measured and the values for V and V/N_{sp} calculated. Similar measurements were made on nine colors prepared using the KCS clay slip and Stayco G starch. Solids were varied from 50 to 60% and starch levels from 12 to 16% on the total solids. These results are tabulated in Table I.

Plots of V/N_{sp} versus V for the Stayco M and Stayco G colors are given in Figs. 3 and 4. In each case, the colors tested do not yield a single straight line but rather a series of straight lines corresponding to the various starch levels studied. It is also apparent that at a given starch level different straight lines are found for the colors prepared with two starches.

These results suggest that the basic concepts inherent in the form of the Robinson equation may be validly applied to coating colors. In other words, coating colors may be considered as suspensions whose

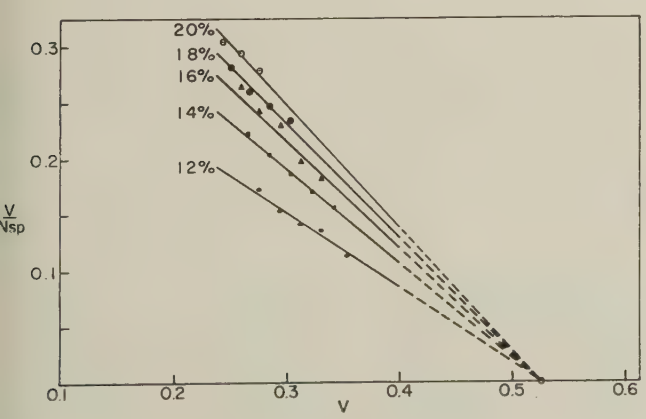

Fig. 3. V/N_{sp} versus V relationship for Stayco M colors

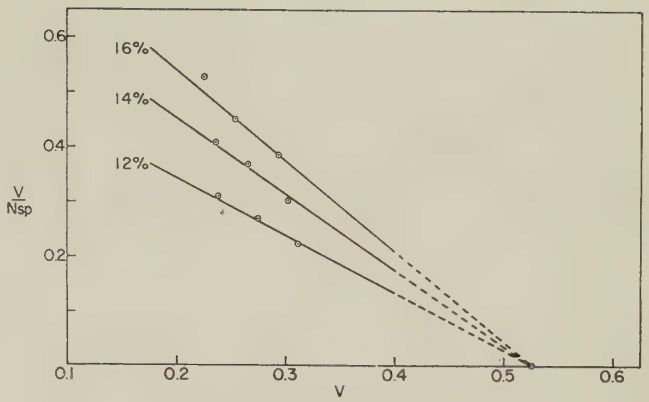

Fig. 4. V/N_{sp} versus V relationship for Stayco G colors

specific viscosities are directly proportional to the volume concentration of pigment and inversely proportional to the volume of free liquid. The fact that series of lines rather than single straight lines were found indicates that the constants k and/or S are affected by such color variables as the level and type of adhesive used.

Characterization of the S Term

Attempts to evaluate the terms k and S involve considerable difficulty. As mentioned previously, the intercepts of the V/N_{sp} versus V lines will give the reciprocals of the constants. However, the experimental errors involved in making the wide extrapolations in this application could yield severely distorted results.

A basic concept in Robinson's derivation is that the S term is equivalent to the relative sediment volume of the dispersed material. This, therefore, provides a means for determining S independently of viscosity measurements. The approach followed in this investigation has been to determine S from direct relative sediment volume measurements and to attempt to confirm the values found by comparison with viscosity data.

A series of 12 Stayco M-KCS clay colors were prepared at solids contents of 20 and 30% and adhesive levels of 10 to 20%. The relative sediment volumes of the pigment in these colors were determined by the direct centrifugal procedure. Results are summarized in Table II.

The differences in the relative sediment volumes found are of a random nature and attributable to experimental variations. It can be concluded from these results, therefore, that the relative sediment volume is essentially independent of changes in color solids or adhesive level. An average relative sediment volume of 1.90 is indicated for the clay in these colors.

A direct measurement of the relative sediment volume

Table III. Determinations of k Term

Starch type	*Starch level, %*	k
Stayco M	12	2.84
	14	2.26
	16	2.03
	18	1.85
	20	1.73
Stayco G	12	1.79
	14	1.37
	16	1.11

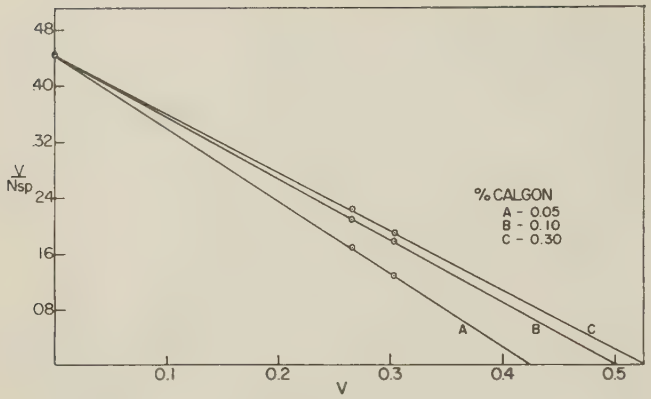

Fig. 5. V/N_{sp} versus V relationship for incompletely dispersed clay colors

of the ball milled KCS clay slip gave a value of 1.88. These results suggest that the relative sediment volume is a pigment characteristic and is essentially independent of adhesive conditions.

If this conclusion is correct and if the S constant is equivalent to the relative sediment volume, the series of straight lines obtained in making the V/N_{sp} versus V plots should have a common intercept on the V axis. This intercept should be the reciprocal of the relative sediment volume (1/1.90 or 0.527).

In Figs. 3 and 4, the straight lines have been drawn to this common V-axis intercept. The fact that the viscometrically determined points and the directly measured relative sediment volume values do combine to yield reasonably good series of straight lines indicates that Robinson's concept of regarding relative sediment volume as a viscosity determining parameter is applicable to coating color systems. These results also imply that S is a constant characterizing the pigment portion of a color and that it is unaffected by the presence of 12 to 20% Stayco M or 12 to 16% Stayco G starch. Theoretical considerations suggest that the S constant must be affected by the degree of pigment dispersion. This matter will be considered in a latter section of this paper.

Characterization of the k *Term*

The k term must vary with changes in the type or amount of starch used in a color. This follows from the facts that the S term has been found to be independent of the amount or type of starch used and that the V/N_{sp} versus V plot has been found to give different straight lines for different amounts or types of starch.

The k terms corresponding to the various levels of the two starches can be evaluated by extrapolating the straight lines in Figs. 3 and 4 to the V/N_{sp} axis. These intercepts give the reciprocals of k. (The previously raised objection to an extrapolation technique referred to extrapolations of just the viscosity data. A significantly different situation exists in the present case since the lines involved are determined by both the viscosity data and the reciprocal of the directly measured relative sediment volume.)

The values found for k by this technique are given in Table III. Little can be concluded about the fundamental significance of the k term. It is dependent upon the starch level and type of starch involved and it is independent of color solids within the ranges of color solids considered in this investigation. These results are consistent with Robinson's definition of k as a constant which is characteristic of a particular suspension system.

Analysis of Incompletely Dispersed Clays

A number of colors prepared with incompletely dispersed clays were examined to determine if the viscosities of such colors could be analyzed in terms of the Robinson equation.

The colors considered previously were prepared using a well dispersed clay slip which had been made by kneading KCS clay with 0.12% NaOH and 0.3% Calgon. Two additional slips were now prepared by kneading KCS clay with the same amounts of sodium hydroxide but with 0.05 and 0.1% Calgon. Coating colors were prepared with these clay slips using 14% Stayco M starch and color solids of 55 and 60%. High shear viscosities of the colors were measured and these results together with results obtained with the corresponding colors prepared with the well dispersed clay are given in Table IV.

Values for S for each of these colors were calculated by substituting the measured viscosities into the Robinson equation and by assuming a constant k value of 2.26. As the calculated values of S listed in Table IV show, results at the two solids levels for each of the clay dispersions were in good agreement. This agreement indicates that the assumption that k is unaffected by degree of dispersion was valid. These relationships are shown graphically in Fig. 5 where it is seen that the reciprocal of k and the experimental points (V/N_{sp}, V) combine to yield three straight lines.

These results indicate that the Robinson equation is applicable to colors prepared with incompletely dispersed clays. In considering such colors the decreased degree of clay dispersion is reflected by increased values of S. The k constant is essentially unaffected by the degree of clay dispersion.

CONCLUSIONS

1. The results of this study have indicated that the Robinson equation may be validly applied to simple starch-clay coating colors containing from 50 to 65% solids and 12 to 20% starch. This implies that coating colors are suspensions whose specific viscosities are

Table IV. Effect of Clay Dispersion on Color Viscosity and the S Term

Calgon used to disperse clay, %	*Color solids, %*	*N_0, cp.*	*N, cp.*	*Nsp*	*V*	*V/Nsp*	*Calculated S*
0.05	55	19.8	51.4	1.596	0.266	0.167	2.34
	60	33.1	112.1	2.387	0.303	0.127	2.35
0.10	55	19.8	45.2	1.283	0.266	0.207	2.00
	60	33.1	90.3	1.728	0.303	0.175	1.99
0.30	55	19.8	43.6	1.202	0.266	0.221	1.88
	60	33.1	86.8	1.622	0.303	0.187	1.91

directly proportional to the volume concentration of pigment and inversely proportional to the volume of free liquid.

2. Robinson's concept that the volume of free liquid is related to the packed sediment volume of the dispersed pigment held for the colors studied. The S term was found to be dependent upon the degree to which the clay was dispersed but independent of color solids, starch level, and type of starch used.

3. The constant k was found to be dependent upon the starch level and type of starch used. Within the solids ranges studied (55 to 65% for Stayco M colors and 50 to 60% for Stayco G colors), k was independent of color solids. This constant was also independent of the degree to which the clay was dispersed. These results are consistent with Robinson's definition of k as a constant which is characteristic of a particular suspension.

PRACTICAL APPLICATIONS

The ultimate objective of this investigation is to develop less empirical coating control practices and more quantitative techniques for handling some of the problems encountered in coating research. The results of this preliminary work have suggested that the analysis of coating color systems in terms of a relationship such as the Robinson equation may provide a means for attaining this objective.

Many of the potential applications of this work to practical problems are dependent upon extending these techniques to colors containing other pigments and various additives and to colors prepared with enzyme converted starches.

Theoretical considerations and the results of several preliminary experiments suggest the following as examples of the types of problems which might advantageously be investigated in terms of the concepts involved in this study.

Starch Conversion Control

When coating application conditions are known to require colors having viscosities within known limits, direct calculations using the Robinson equation will permit a quantitative indication of the degree of starch conversion uniformity required. In formulating new colors, a similar technique would provide a good approximation of the starch viscosity needed to obtain the desired final color viscosity.

Pigment Dispersion Measurements

The calculation of the S term from viscosity measurements provides a numerical indication of the degree of dispersion of the pigment in a color. A comparison of the relative sediment volume measured directly on a pigment slip and the S term calculated from the color viscosity provides a means for detecting pigment flocculation or dispersant redistribution effects. For example, clay slips prepared with 0.1 and 0.3% Calgon were found to have similar relative sediment volumes. The viscosities of colors prepared with these clay slips, however, indicated S terms of 2.00 and 1.90, respectively.

Pigment Characterization

The analysis of colors prepared with different clays or different pigments will indicate whether two pigments differ in their response to dispersing treatments or whether there are more fundamental differences in their viscosity behavior.

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Sampling in Lieu of Sheet Sorting

F. G. CRANE, JR.

The advantages of sampling over sheet sorting in areas of both cost and quality are shown. Two serious problems which must be considered before sampling can be adopted are very low tolerance of certain defects and the nonrandom nature of some others. Possible ways of overcoming these problems are suggested.

In the fine paper industry, product quality has long been assured by 100% sorting of sheets of finished paper. Various methods of sorting and sorting machines have been devised to reduce the cost and improve the reliability of this final inspection (*9*). Despite the many improvements in sorting, it still suffers from several faults and represents an area which statistical sampling techniques should be able to improve. This paper is written to illustrate the advantages of sampling in this area, some of the problems encountered, and to suggest some possible solutions.

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One-hundred per cent sorting suffers from two basic problems which can best be classified in terms of cost and quality. From the point of view of expense, sorting can add between 5 and 15% to the cost of the finished paper due to labor and extra handling. It is perhaps not so well known that it also suffers from satisfactory quality assurance. The quality level of paper leaving the sorting area is very markedly influenced by the per cent defective of the paper produced, as shown by Fig. 1. A similar curve can be drawn for the per cent defective of the broke. In other words, as the quality level is improved, a higher proportion of acceptable paper is rejected. Hoffman (*1*) has defined methods for improving the quality of sorting to give much better quality assurance. Sorting also suffers from the difficulty of maintaining accurate quality standards (*7*, *8*). In order to reduce sorting costs, sorting speeds are sufficiently high to prevent the sorter from checking against standard samples or from classifying defective sheets. Samples can be inspected economically at

speeds which allow the inspector to refer to accurate standards and, therefore, assure accurate classification of defects.

An analysis of a typical sorting room performance is given in figures below. Figure 2 shows the distribution

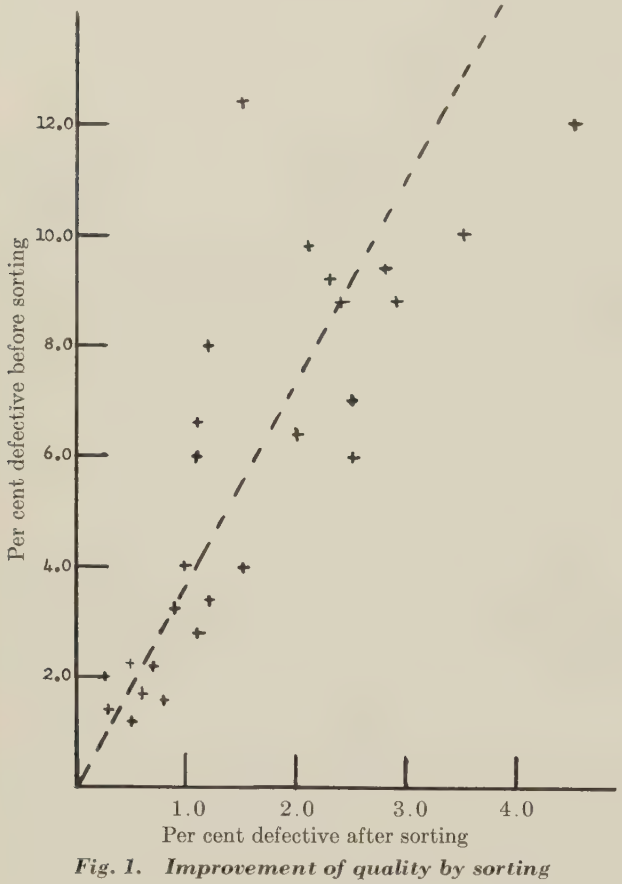

Fig. 1. Improvement of quality by sorting

of lot average quality after sorting over a period of a year in one particular grade. The distribution shows the effects of some very poor lots. Table I shows the

Table I. Average O.Q.L. of Five Sorters

Sorter	*Average per cent defective*
A	2.2
B	0.5
C	3.1
D	1.4
E	2.4

outgoing quality level of five sorters on the same lot of paper, showing the varying ability of different sorters to find defective sheets. From these figures, it would not seem difficult to improve upon this picture from a quality standpoint.

STANDARD SAMPLING

It must be borne in mind that a sampling plan will merely accept or reject loads or rolls of paper which meet certain quality requirements. The units which are rejected must then be 100% sorted. The first step, consequently, must be to make certain that the average quality produced is satisfactory to meet customer requirements. It is not the purpose of this paper to go into detail on the subject of machine or finishing control, except to say that it is the most essential first step. Aspects of this problem have been covered by others (*2*). With adequate control of production, the per cent defective of rolls in a lot will show a typical distribution, such as Fig. 3. This run, before sorting, is better than the average quality after sorting. It is, therefore, doubtful if cost of sorting is justified. If those rolls with the high percentage defective can be detected by sampling and, therefore, eliminated, a higher level of quality can be obtained.

A typical sampling plan designed to give an average outgoing quality level of 1.5% is the following: sample size 300 sheets from each load; three loads cut from each roll to give a total sample of 900 sheets for the roll; accept the roll if there are 20 or less defective sheets; accept no rolls from lots showing less than 60% acceptance. The operating characteristic curve of this plan is shown in Fig. 4. In this connection, a p chart for per cent defective in each roll sample is helpful. The information gained from such a chart will give a good indication of the quality of paper produced, whether the production is in control and whether or not nonrandom influences are in effect. Figure 5 shows a typical p chart with its accompanying limits. The average per cent defective for the lot is 2.1%. Rolls 1, 2, and 3 are obviously much worse and should be rejected. The other rolls show good control with an average per cent defective of 1.8. However, the sampling plan is set to accept no more than 20 defects, so three more rolls may be rejected. The chances are that these rolls are from the same population as the others. However, the decision to sort or not sort would depend on the nature of the defect and the customer. To further insure the quality of paper being shipped, precaution should be taken to

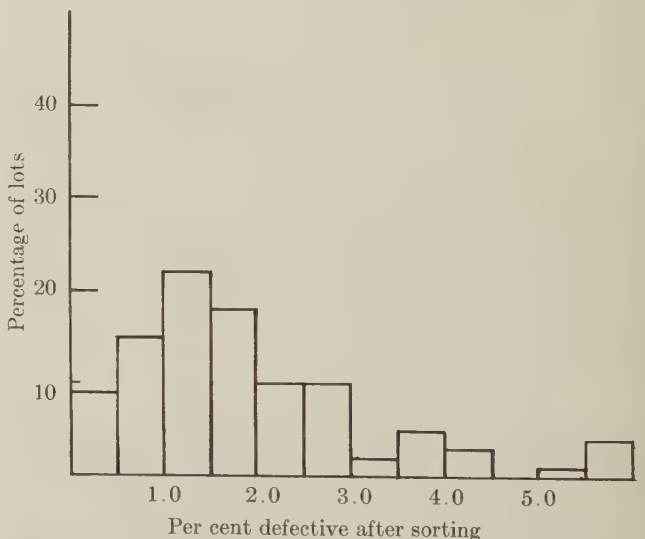

Fig. 2. Quality distribution—12 months one grade

mark those loads which are poorly jogged or show other evidence of being off-quality and isolate of those areas within the load which may be suspected of having off-quality paper. Paper near the core, paper in the vicinity of a break, and oftentimes paper at the top of a load are areas which should be suspected, and

paper in these areas should be rejected for sorting. Education of machine and sheeter operators is essential, to insure that off-quality paper is properly marked.

SAMPLING FOR MAJOR AND MINOR DEFECTS

Such a plan as this can work well in some cases; however, if the majority of cases were as straightforward as this, sampling would long since have been an accepted practice in the paper industry. There are two separate and distinct problems which must be considered and which complicate the solution by sampling. The first of these is the fact that all defects are not of equal importance to the customer. Spots, dirt, small wrinkles, etc., can be tolerated to a far greater degree than certain others, such as holes, torn sheets, etc. The common visual defects must be classified into major and minor categories, depending

Table II

	Technical defects		*Visual defects*
Major—	Nonflat paper	Major—	Torn sheets
	Physical strength specifications		Creases
	Loose particles		Holes
			Lumps
			Sticky rubber
Minor—	Moisture	Minor—	Holes
	Off weight		Lumps
	Poor trimming		Sticky rubber
			Dirt specks
			Grease
			Scale
			Wrinkles

on the difficulty they cause to the consumer. I would suggest the following definitions: a minor defect is one which affects the quality of only one sheet or part thereof; a major defect is one which affects the quality of a number of consecutive sheets, causes excessive down time to the customer or reduces his operating speeds. Most major defects fall into the category covered by specifications. Thickness tests, pick tests,

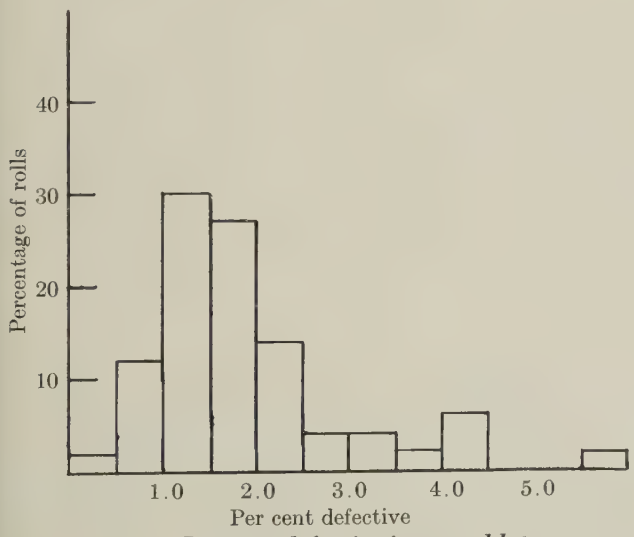

Fig. 3. Per cent defective in a good lot

moisture tests, curl specifications, etc., are examples. There are, in addition, several visual defects which can fit into this category. The assignment of major and minor classifications and the tolerance level of these defects must be done in cooperation with the customer.

This problem and its solution can be illustrated by an example. Our company has set up a sampling plan with a customer which has worked well. Before setting it up, the customer listed the defects and assigned some measure of the seriousness of each one—

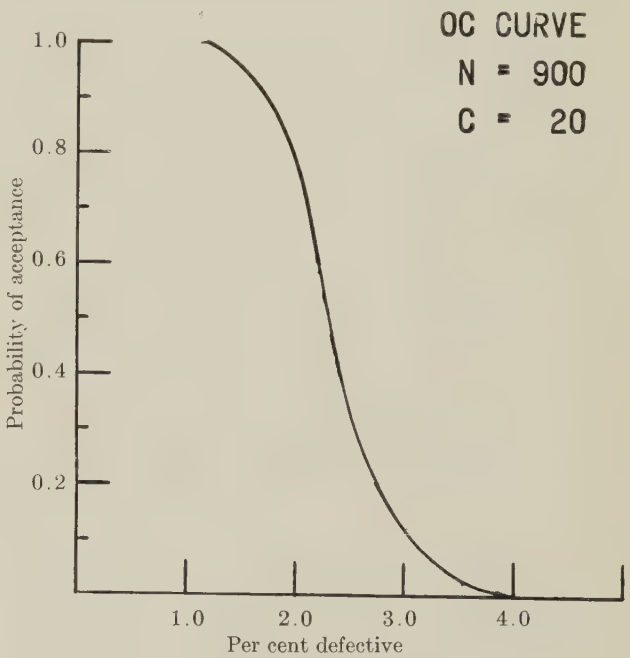

Fig. 4

some form of cost data is helpful. This list was then broken down into two groups—one was strictly a manufacturing control problem, in that this type of defect could not be detected and removed by sorting; the other group was those defects which could be removed by sorting. These groups were then divided into major and minor categories. Table II shows the results. Unfortunately, the customer had no adequate method of determining the frequency with which these major defects had occurred in the past. The only information available was from our own audit inspection. These data are, unfortunately, too sketchy to give accurate estimates of such low frequency. An estimate of the frequency is tabulated in Table III.

Table III

Major defect	*Fraction defective*
Torn sheets	<0.0001
Creases	0.0001
Holes	<0.0001
Lumps	0.001
Sticky rubber	0.0004
	0.0015

The very low percentage of major defects indicates that sorting is a good deal more effective for this type of defect than it is for the more frequent minor defects. The very low occurrence of these defects was borne out by discussion with the customer who indicated he could tolerate no more than the past level due to the high cost of these defects. Sampling for such low percentage defective is extremely difficult and would result in no cost savings.

The solution to the problem lies in the nature of these

major defects. Certain defects, such as torn sheets and wrinkles, can be removed by adequate marking on the machine and subsequent removal at the cutter. Serious creases occur in the area of reel starts and breaks, etc., and these sections of the load should of

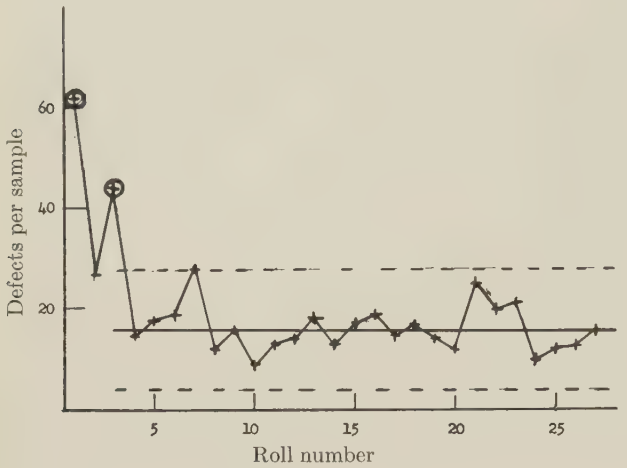

Fig. 5. Control chart for per cent defective

necessity be sorted. Heavy wrinkles usually run until detected and can thus be located in the roll and also can be located generally by a rough examination of the ends of the load. To further remove the possibility of these defects passing into finished paper undetected, automatic devices are available to continuously check the paper on the machine. It is claimed that the use of these devices, Detectron void and lump detector and Viking void detector, to name two, will record the frequency of occurrence and location in the roll. Automatic detection of these defects can improve the reliability of sampling. Other major defects in this case are mostly a matter of degree and are, therefore, associated with more common smaller defects which are of minor severity. Correlation studies indicate that limits set on these smaller defects can give reasonable assurance of meeting tolerance levels on the major defects. Large lumps are not present without being accompanied by a large number of minor lumps. The same situation applies to sticky rubber. Holes are also associated with a certain type of lump. When samples are inspected, defective sheets must be classified into groups —by setting limits on the number and type of lumps and rubber specks allowed in the sample, loads which may contain major defects are eliminated. On the limited data available at the time of writing, it would appear that correlation between major and minor defects should be checked on individual grades as it does not seem to be uniform. This is no doubt due to the fact that stock and machine conditions used to run the various grades effect the frequency and relationship between major and minor defects.

NONRANDOM DEFECTS

The second major problem to be solved before adequate sampling can be carried out is to determine the degree to which defects occur in a random fashion within a roll. It is obvious that certain defects such as tear-outs, wrinkles and others, by nature are nonrandom. The areas where tear-outs and wrinkles occur must be located within the rolls as indicated above so that they may be removed. Carlson (*3*) has given methods for determining the randomness of defects in loads. Loads are analyzed by locating the defective sheets by number. The number of sheets between defects can be checked for randomness by the method of runs or signs (*5*, *6*). Using this analysis, the breakdown of defects and the extent of nonrandomness in the example mentioned is shown in Table IV. Both lumps and scale show significant evidence that there is a degree of nonrandomness in their occurrence. This is no surprise to those familiar with machine operations. It is helpful, however, to find that approximately

Table IV

Defect	*Frequency of nonrandom occurrence, %*
Lumps	22
Scale	23
Rubber	0
Knots	7
Dirt	0

80% of this type of defect is random. To be safe, the evidence of nonrandom defects necessitates somewhat tighter acceptance limits on these two types. In this particular case, tight limits are already necessary due to their association with major defects. Burr, Norris, and Sullivan (*4*) have discussed methods of sampling in nonrandom distributions. It is quite possible that variations of their techniques might work well in this particular case. Since the large majority of occurrences are of a random nature, one can feel reasonably safe in using standard sampling so long as there is no good evidence of nonrandomness. The p chart in Fig. 5 is one possible means of detecting nonrandomness in the run. If there is good evidence of nonrandom influences as indicated by runs, or too many points on either side of the mean (*5*, *6*), the run should be sorted. A further safeguard is to reject those loads or lots where the principal defect is scale or another defect with a known nonrandom distribution. Sampling will be in error to the extent that the defects are nonrandom. In the case of scale, it is random 75% of the time and, therefore, if there are sections of the load containing a heavy nonrandom accumulation, they should be indicated by a considerable quantity in the sample sheets.

In general, it should not be necessary to use all these precautions on any one grade. However, before setting up a sampling plan, it is well to determine whether or not they are necessary.

CONCLUSION

This paper has attempted to establish the fact that there is considerable room for improvement over 100% sorting of finished paper. Sorting is expensive and does not always assure adequate outgoing quality. Statistical sampling techniques offer a possible means of both reducing the cost of quality as well as giving better assurance of outgoing quality. There are two basic problems to overcome before sampling can give adequate protection: these are, the necessity for very low tolerance levels of certain types of defects and, secondly, certain defects do not always occur in a random fashion. Before establishing a sampling plan to replace sorting, the following steps should be followed:

1. Classify defects into major and minor defects.
2. Determine the customer's tolerance level for major defects. If possible, this should be done with customer cooperation, otherwise, a study of present outgoing quality level for major defects will be sufficient.
3. Those defects with very low tolerance level must be detected by other means than sampling. Methods of doing this by correlation with more frequent minor defects and the use of mechanical devices are suggested.
4. The distribution of defects in loads can be analyzed as outlined by Carlson. Certain types of defects are not random and must be prevented or adequately marked when they do occur. Other defects may show a degree of nonrandomness which may cause trouble.

It is hoped that this paper will aid those who are interested in establishing sampling plans. Despite the above-mentioned difficulties, sampling is being used in several mills today with satisfactory results.

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The Venturi-Scrubber on Lime Kiln Stack Gases

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The literature on dust losses and scrubbers for lime kilns has been reviewed. Comparative test data are given on a number of units, including the Pease-Anthony Venturi Scrubber and a recent modification of that unit called the CHEMICO S-F Venturi Scrubber. Efficiencies of approximately 99% removal of lime dust are achieved at relatively low pressure drops of 6 to 10-in. w.g. across the unit and heavy slurries are used as the scrubbing liquor in the CHEMICO unit. Tests showed 63 to 80% removal of soda fume which is volatilized at the hot end of the kiln and has a smaller particle size than the larger lime dust mechanically entrained in the kiln gases. Because of the high soda content of the lime sludge burned in the kilns at Palatka, a further reduction of soda losses appears possible by improved washing of the sludge.

LITERATURE REVIEW

THE dust from lime kiln stacks, slakers, lime conveyors, etc. has been a major nuisance of sulphate pulp mills. In view of efforts to achieve high efficiency in the removal of soda fume from the kraft recovery furnace stack gases, it is remarkable that the problem of collection of the larger lime dust particles has not been investigated as thoroughly, at least insofar as the literature shows.

Dry Cyclones

The early work of this author (*1*) on dust collection for lime kilns was the application of the Multiclone for a pilot plant study. Exit dust loadings ran 1.4 to 2.6 grains per cu. ft. wet gas at STP and indicated a 70 to 78% removal of calcium compounds which was not considered so high as would normally be desirable. However, for practical purposes it was sufficient since it was necessary to leave the sensible heat in the lime kiln stack gases to reduce condensation in the recovery stack.

A later paper by Collins and West (*2*) gave data on the quantity of heat in the lime kiln stack gases that would be available for heating water in a wet scrubber of the condensing-type. A full-scale Multiclone installation that operated at approximately 70% dust removal efficiency for a number of years at Thilmany was also described. With the installation of a larger kiln in recent years, the Multiclone unit was enlarged.

Mocine (*3*) has described a Multiclone installation on a rotary kiln for calcining limestone. The dust collector pressure drop was 2.6 in. of water and had an estimated collection efficiency of 95% on dust, 85% of whose particles by weight passed a 325-mesh screen.

An installation of multicyclones on lime kiln gases has been mentioned by McGlothlin (*4*). Although efficiencies of as high as 98% removal of lime dust were achieved for a short time, the units tended to plug and get out of balance and this difficulty was not overcome. (*Author's note:* plugging of Multiclone tubes has been reduced on some installations by hanging a chain in each unit to keep the bottom of the collecting tube scoured free of dust buildup.)

Mockridge (*12*) has stated that the fines not removed by large cyclones on lime kiln gases may run from 2 to 4 grains per cu. ft. at 60°F. and that they do not do an acceptable cleaning job. Brown (*4A*) claimed that dry cyclones remove only the coarse particles above 5 mu so are not desirable for lime kilns.

Wet Scrubbers

An efficiency of approximately 80% fume removal from a lime kiln by means of cyclone-type equipment with sprays was mentioned by Swartz (*5*).

Benin (*6*) has described an apparatus for scrubbing lime kiln gases in sugar factories. Other equipment for this purpose has also been patented (*7*).

In his paper on lime kilns, Walker (*8*) pointed out that soda is volatilized in the hot end of the kiln and condenses in the cold end, thus setting up a circulating

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load of sodium compounds in the kiln. The use of wet scrubbers was suggested with the kiln gas being used to heat water. A 10% solids slurry was recirculated and bled off from the scrubber to the mud washer or the slurry was held in a settling tank and the underflow returned to the sludge filter. A loss of 20 lb. of calcium carbonate per ton of pulp after a spray chamber was noted by Brown (*4A*). The soda loss was said to be serious but not sufficient to warrant the cost of installing an electrostatic precipitator.

The type of cyclone scrubber used on many Allis-Chalmers kilns was shown in the article by Tock (*9*), who recommended placing the draft fan after a dry dust collector or ahead of a wet scrubber to minimize corrosion and erosion from condensing water vapor. The scrubber shown is a top tangential inlet, cylindrical vertical cyclone with spray nozzles for recycled slurry in the top of the cyclone. For a kiln producing 100 tons of lime a day, this type spray chamber was sized at 18 ft. diam. by 20 ft. high having 20 spray nozzles recirculating 250 g.p.m.

A Bartlett-Hayward scrubber-humidifier capable of handling 20,000 c.f.m. of kiln gases containing 13 lb. lime dust per min. and cooling the gases from 550°F. to 90°F. has been used on a sludge kiln at Miami (*10*) for a water treatment plant. The hot gases pass to a humidifier equipped with two spray nozzles discharging against a deflector plate and then into the bottom of an 8 ft. diam. by 50.5 ft. high, wooden grid-packed tower. Cold water enters the top of the tower and cools the gas to condense a large portion of the vapor and remove dust.

A number of installations of the Peabody scrubber have been made on lime kilns (*11*, *12*). One unit (*11*) followed a Traylor scrubber that consisted of a counter-flow tower packed with wooden grids. The Peabody unit for a 160 tons of lime per day kiln was 10 ft. diam. by 23 ft. high handling 103,000 c.f.m. at a gas cleaning efficiency of 98 to 99%. Fresh water was used on the scrubbers. In a typical unit described (*12*) the dirty gases enter the bottom and pass up into a spray zone; then into the spray aspirating slot stage; above that into the impingement plate stage; and thence to the entrainment separator. Recirculation was said to make possible as low as 20% fresh water make-up if the scrubber discharge was partially clarified. For a 250 tons of lime per day kiln the gases left the scrubber at 150°F. with a pressure drop of 4.5 to 5.5 in (water column) at a gas flow of approximately 26,000 c.f.m. std. at 60°F. The inlet gas dust loading was 16 grains per std. cu. ft. of dry gas while the discharge was 0.3 to 0.4 grains for an over-all dust collecting efficiency of about 97%.

The Type N Roto-clone manufactured by the American Air Filter Co., Inc., has also been used for scrubbing lime kiln gases. Porter, Bishop, and Liskow (*13*) have described the preliminary pilot plant studies and the first full-scale installation. This unit utilized a pressure drop of about 6 in. of water across the "impellers" and reduced the new lime make-up from 156 to 15 lbs. per ton pulp. It was also credited with a saving of 1375 tons of salt cake per year by trapping the soda fume in the scrubbing solution. The lime sludge fed to the kiln contained about 2.2% Na_2O based on dry solids and tests showed that previously 80% of this sublimed and was lost in the stack gases with the lime dust. The sampling apparatus used in the test work passed the gas through cyclones and then through alundum dust collection filters. The Roto-clone was also mentioned by Brown (*4A*).

The Pease-Anthony cyclonic scrubber has been used on about 30 rotary and shaft kiln installations burning limestone and some of them have been described (*14*). Installations at the Niagara Falls plant of the Electro Metallurgical Co. on rotary lime kilns (*15*) have shown dust removal efficiencies of 98 to 99.4%. Three scrubbers for 29,000 c.f.m. each capacity are 12 ft. diam. by 33 ft. high. The 22 water spray nozzles in each unit use approximately 400 g.p.m. of water with pumps and fan requiring about 140 hp. Inlet gas is cooled from 1350°F. to 450°F. by scrubbing. The scrubbers and inlet flues are firebrick lined to withstand these temperatures. Another article (*16*) on materials of construction points out that kiln scrubbers do not suffer mild steel shell corrosion if kilns are fired with natural gas of low sulphur content. One on a high sulphur coal fired unit corroded rapidly and it was found that a Gunited lining of Aluminite cement offered protection. (*Note:* The author is familiar with a steel-shelled lime kiln scrubber which corroded rapidly in a pulp mill burning high-sulphur oil. The lime sludge had been washed to a low content of residual sodium alkali.)

A recent study has been presented by Semrau (*17*) covering a pilot plant comparison between three types of wet scrubbers on lime kiln stack gases and recovery furnace fume. The units investigated were the Pease-Anthony venturi and cyclonic scrubbers and a so-called "pipe line scrubber." The author pointed out, as have others, that the dust from lime kilns consists of two components: mechanically-entrained lime particles of relatively large particle size and a fine fume of sodium compounds volatilized at the hot end of the kiln. Sampling was done with a heated holder containing a paper thimble. The pilot plant units were tested on the stack gases directly from the kiln or after a type of prewasher which left primarily the residual dust in the gases as soda fume.

This author offered a considerable theoretical discussion of subject of scrubbing and rather than expressing his results in percentage scrubbing efficiency or even giving the exit dust loadings at different power requirements (pressure drops in gas flow across the units plus pumping power, etc.), he related the theoretical power input to the number of "transfer units" which is a measure of the difficulty of collection over the complete range of efficiency from 0 to 100%.

The tests covered a considerable range of pressure drops across the units. The problem of dust removal (particularly for the prewashed gas) was similar to that for soda removal from kraft recovery stack gases rather than normal lime kiln dust. The data in the original paper are so extensive that the reader is referred to it.

STUDIES OF COMMERCIAL SCRUBBING EQUIPMENT AT PALATKA

P-A Venturi Scrubber

Hudson Pulp and Paper Corp. several years ago

installed two 200 ft. by 7 ft. diam. kilns of 60 tons of lime per day rated capacity each. These kilns were equipped with a primary dust chamber in which recycled slurry and water were sprayed, followed by a second separating chamber originally packed with wooden grids which were later removed. Slurry was also sprayed into the gas stream in the passageway between the two towers. This was the typical design of scrubber furnished by Traylor, the manufacturer of the kiln.

A test on the gases leaving the scrubbers on the

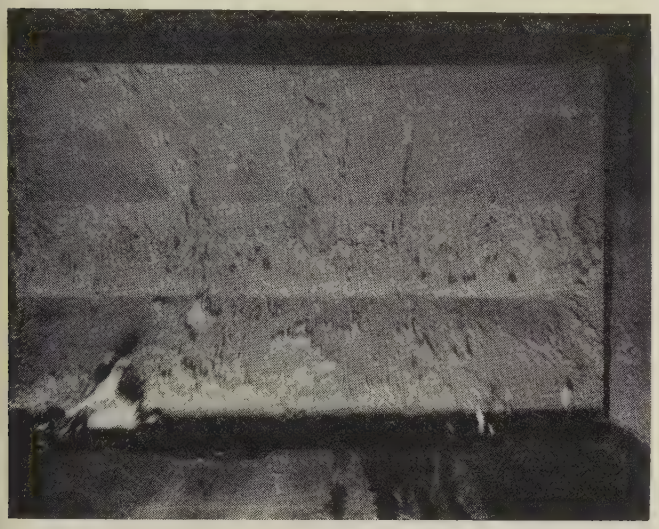

Fig. 1

kilns showed that a considerable portion of the solids being lost consists of sodium salts. This was to be expected as the lime sludge fed to the kilns at Palatka carries 1.7 to 2.7% Na_2O due to inadequate washing. There is no doubt that this fine soda fume is volatilized to a great extent at the hot end of the kiln independently of the mechanical carryover of lime dust. It probably compares in particle size with kraft recovery furnace fume rather than the considerably larger lime particles.

Because of the high loading proportion of soda fume, it was decided to install a full-scale Pease-Anthony Venturi Scrubber for investigation of its operation at a relatively low pressure drop comparable to that for other scrubbers used on pulp mill lime kilns. The unit was arranged to operate on mill supply water without recycle and to scrub the gas by-passed around the previously installed scrubber. A comparison of the dust losses from the Traylor scrubber and the P-A Venturi Scrubber is given in Table I.

Since this scrubber was not originally provided with filters or jet-hole reamers on the manifold, it was difficult to operate on the debris-filled water available. In addition, the scrubbing water volume was too great to be handled in the existent facilities of the causticizing system which used hot water from another source. As a result of this, further investigation was dropped with the idea of making the necessary changes on a second unit under construction on the new 250 by 8.5 ft. diam. kiln, designed for reburning 120 tons of lime per day. This no. 3 kiln scrubber was equipped with throat spray manifolds having jet-hole reamers individually operated by hand. The approach cone was washed with fresh water sprays to prevent build-up by removing the wet-dry line in the venturi throat.

Table I. Operating and Performance Data on No. 2 Kiln Scrubbers

	Original scrubber		*P-A Venturi scrubber*	
	Max.	*Min.*	*A*	*B*
Outlet gas dust loadings				
$CaCO_3$, grains/cu. ft.[a]	2.25	0.57	0.006	0.003
Na_2CO_3, grains/cu. ft.[a]	0.57	0.24	0.031	0.18
$CaCO_3$, tons/day	3.65	0.87	0.007	0.004
Na_2CO_3,[b] tons/day	0.87	0.35	0.32	0.19
Scrubber operation				
Inlet gas, c.f.m.—duct cond.	...	...	16,600	18,300
Water to venturi g.p.m.	...	...	164	263
Differential across venturi and cyclone in. w. g.	...	...	5.0	9.25

[a] Wet gas at STP (32°F.—29.9 in. Hg).
[b] Approximately 20% of the sodium can be calculated to salt cake on the basis of the total sulfur compounds present in the dust sample solution.

An attempt was made to operate this unit on recycled dust slurry using only about 60 g.p.m. of fresh water in the approach cone showers for make-up. Due to debris in the creek water used, as well as lime sludge lumps, it was not wholly satisfactory to operate the unit on recycled slurry because of the necessity for the operator to ream the jet-holes frequently. Consideration was given to the possibilities for using timer-actuated mechanical reaming, a clarifier, a filter, or even centrifugal cleaners to remove the lumps and debris from the scrubbing slurry but a simpler and less

Fig. 2

expensive solution to the problem appeared desirable. It was also of paramount importance to arrive at an arrangement which would give a minimum of water returned with the dust from the kilns since it was not desirable to use much hot water from the lime kiln area.

Chemico S-F Venturi Scrubber

To modify the venturi scrubber to meet the limitations imposed by the Palatka system and to keep the equipment practical to operate and at lowest cost for auxiliary equipment, a form of the venturi scrubber

developed in Sweden by A/B Svenska Flaktfabriken (*18, 19*) and marketed in the Western Hemisphere by Chemical Construction Corp. was recently installed. This unit differs from the conventional P-A Venturi Scrubber in that a wet-dry line eliminator is used and the scrubbing liquid mixed with the gas in the throat is not injected as jets from an outside manifold.

The wet-dry line eliminator consists of a sleeve extending down into the inlet of the vertical venturi-atomizer to carry the gas in without touching the wall until it is covered by a film of liquid. The scrubbing liquid is fed onto the sloping wall of the venturi inlet from a trough running around the inside of the outer wall above the level of the bottom of the sleeve. Liquid is fed to this trough through large pipes from the pump so there is little, if any, possibility of plugging the slurry circulating system with debris from the water make-up or lumps of lime sludge.

The liquid cascading down the inlet walls of the venturi strikes a rim projecting from the wall at the throat. This turns the stream and shoots it across the throat to form a wall of fluid against which the gas impinges the dust and where it mixes under conditions of high turbulence as the liquid is being broken up into small droplets. Figures 1 and 2 show the throat when lime sludge slurry was being circulated through the unit. In Fig. 1 there is no induced draft of air through the throat. In Fig. 2, at a high liquor rate and relatively low air velocity in the throat, the atomization of the liquid into droplets can clearly be seen.

A schematic diagram of the Chemico S-F Venturi Scrubber as finally installed on no. 3 lime kiln at Palatka is shown in Fig. 3. The actual installation does not use the bottom of the cyclone for the scrubbing slurry sump as shown but an outside sump in the ground with a submerged pump is used. There is a dust hopper on the end of the kiln with a bottom cone continually flushed with recycled slurry to the sump and the venturi is over on one side. At present a Foxboro magnetic flowmeter is used to indicate and record the flow of slurry to the venturi. Although the meter is excellent for this service. it can be replaced, for practical purposes, with a calibrated weir in the system. Since slurry entering the throat of the venturi-atomizer acts as a damper, a throttling valve on the circulating line can be connected with the draft controller at the hot end of the kiln. Thus the pressure drop available from the fan for the gas stream can be fully utilized in atomizing slurry for the highest efficiency of dust removal. It is also necessary that the mechanical damper on the fan outlet be tied in with the draft controller so that in case of slurry pump failure the damper will take over before the draft on the kiln gets too high.

The scrubbing slurry make-up at the present time is approximately 7 to 10 g.p.m. of water fed into the sump through a Rotameter. This amount of water is sufficient to maintain a filterable solids concentration in the slurry not exceeding 45% which is suitable for scrubbing. The concentration of slurry depends upon the dust load to the scrubber relative to the water

Table II. Test Data, No. 3 Kiln Chemico S-F Venturi Scrubber

Inlet gas temperatures, °F.	309–344
Exit gas temperatures, °F.—sat'd	156–168
Scrubbing slurry temperatures °F.	155–166
Inlet gas volume, c.f.m. at STP—32°F., 29.9 in. Hg.	17,400–24,700
Inlet gas volume, c.f.m. at duct conditions	27,800–40,000
Outlet gas volume, c.f.m. at STP—32°F., 29.9 in. Hg.	20,400–25,800
Outlet gas volume, c.f.m. at duct conditions	26,200–32,800

	Run no. 1	4	5	6	7	8
Pressure drop across venturi and cyclone, in. w.g.	11.25	6.75	10.75	6.75	5.5	5.5
Scrubbing liquid used	Filtrate	Filtrate	Slurry	Slurry	Slurry	Slurry
Scrubbing liquid, g.p.m.	510	290	410	160	200	100
Scrubbing liquid, % solids	3.3	...	46.7	18	...	...
Inlet dust load, tons/day						
Acid insoluble	0.08	0.16	0.06	..	..	...
$CaCO_3$	4.14	14.70	19.62	...	...	...
Na_2SO_4	0.30	0.03	0.06	...	...	...
Na_2CO_3	2.34	2.41	1.64	...	...	...
Total	6.86	17.30	21.38			
Outlet dust load, tons/day						
Acid insoluble	0.01	0.05	0.02	0.01	0.09	0.03
$CaCO_3$	0.03	0.10	0.15	0.15	0.08	0.37
Na_2SO_4	0.04	0.01	0.02	0.02	0.02	0.01
Na_2CO_3	0.86	0.48	0.45	0.75	0.30	0.31
Total	0.94	0.64	0.64	0.93	0.49	0.72
Dust loadings, grains/cu. ft.[a]						
Inlet	2.94	6.86	11.94	...	...	...
Outlet	0.45	0.24	0.30	0.40	0.18	0.27
Dust removal efficiency %						
For $CaCO_3$	99.3	99.4	99.5	...	...	...
For Na_2SO_4	86.5	63.3	59.6	...	..	...
For Na_2CO_3	63.0	80.0	72.5	...	...	...
Over-All	86	96	97	...	...	..

[a] Wet gas at STP—32°F., 29.9 in. Hg.

make-up and bleed-off. The slurry level in the sump is controlled by a float which at the top of its travel actuates an air controller to throttle open a slurry bleed-off valve to the mud washing system. At the bottom of the float travel the bleed-off valve closes and an air controller throttle opens a fresh water

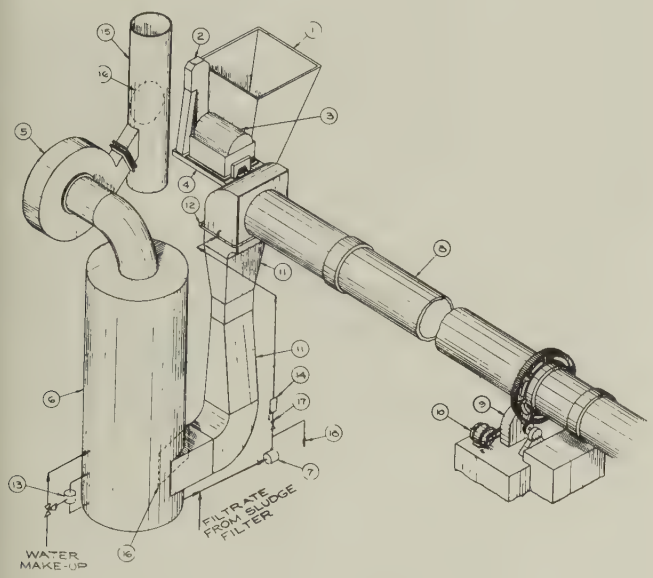

Fig. 3. Chemico venturi scrubber installed on kiln exhaust gases

(1) Stone bin. (2) Bucket elevator. (3) Filter for sludge. (4) Spiral conveyor. (5) Induced draft fan. (6) Cyclonic separator. (7) Recirculation pump. (8) Rotary kiln. (9) Gear reducer. (10) Motor. (11) Chemico venturi scrubber. (12) Manifold for slurry feed. (13) Level control. (14) Magnetic flowmeter and recorder. (15) Stack. (16) Damper (controlled by hot end draft controller). (17) Valve to control slurry recirculation. (18) Slurry to process.

make-up valve. This eliminates troublesome plugging of the bleed-off valve which occurs if it is set manually at fixed position. Originally the filtrate from the kiln sludge filter passed into the sump and out again to the mud washer so that there was no fresh water make-up to the scrubbing system. If necessary, the slurry to the sludge filter could be used for scrubbing to pick up the dust and carry it to the filter and also to increase the temperature of the slurry to about 150 to 160°F. Various other schemes of control may also be used to enable the scrubber to heat a supply of water for the mud washer as well as the filtrate. At Palatka the filtrate temperature presently is about 105 to 115°F. so it appears desirable to heat it with the lime kiln stack gases.

A number of tests have been run on this unit using a wet collecting procedure for sampling as described in previous publications of the author (*20*, *21*) with very slight modifications. The calcium was determined by titration with Versenate solution and indicator after removal of iron from the sample. Total soda was determined gravimetrically with zinc uranyl acetate reagent and the sulphate turbidimetrically with barium chloride after oxidation of the sulphur compounds in the sample with bromine water. Table II gives the data from these tests.

These data indicate that this type of unit does an excellent job of dust removal, particularly where the comparatively large particles of lime dust are involved. For higher efficiency of removal of soda fume under present conditions it would be necessary to operate at somewhat higher pressure drops across the venturi and probably with the conventional P-A Venturi Scrubber for highest efficiency. Information on units operating on recovery furnace stack gases containing soda fume at higher pressure drops than available for this study is available in prior publications (*20–24*).

It is quite apparent from this study that the need at Palatka is not for a more efficient scrubber but for improved mud washing, either on the filters or by the addition of a second stage mud washer. In addition to reducing the soda fume loss from the lime kiln stacks, a soda content lower than the present 1.9 to 2.7% Na_2O in the sludge to the kiln should decrease the considerable difficulty of rings and balls in the kiln.

The simplicity of design, operation, and maintenance of the CHEMICO S-F Venturi Scrubber; the high efficiency of lime dust removal at a reasonable expenditure for power on the fan and pumps; and its ability to wash the gases with a slurry of high suspended solids concentration carrying lumps of lime and debris warrants consideration of this unit as a practical solution to the problem of dust losses from lime kilns.

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Parallel Sectioning of Newsprint

R. L. WOOD

A method was developed for sectioning of newsprint parallel to its surface and subsequent mounting of the sections. Serial sections 12 mu thick were cut giving a total of seven sections through the sheet. Thicker or thinner sections could be cut. The technique involved embedding the sample on a block of wood previously cut flat in the microtome. A blend of 40 parts polyethylene and 60 parts microcrystalline wax was used for embedding. The cut sections were mounted on microscope slides. The sections were stained with methylene blue and permanent mounts were made in Canada balsam. Photographs of these sections showing location and orientation of the fibers are shown. These pictures also show a set of seven serial sections from a sample with a slight wire mark and from a sample with a severe wire mark. The wire mark can be seen in five sections on one and in only one section on the other. This technique is not restricted to newsprint and should be useful in gaining information about sheet structure of other grades.

TODAY'S high-speed paper machines and the constant demand for better quality have increased the need for knowledge about the formation of paper. Paper sectioning is one method which has been used to study fiber formation. Cross-sectioning techniques have been developed to the point where sections of almost any desired thickness can be obtained (*1*, *2*, *5*). Our objective was to find if any relationship between the severity of wire mark and fiber formation in newsprint could be found. A large number of fibers have to be examined to find any relationship. Low power magnification is adequate and allows larger areas to be examined. Sections parallel to the surface allow a relatively large number of fibers to be seen at one time. With this in mind, a method was developed for obtaining these parallel sections.

Previous work in parallel sectioning has been done for the study of filler distribution and starch penetration (*3*). This work was done by cementing the paper sample to a block of softwood mounted on a microtome stage and previously cut flat. The technique developed for parallel sectioning of newsprint at Crown Zellerbach's Central Research Department combined the methods previously used for parallel sectioning with the embedding techniques commonly used in cross sectioning.

CUTTING AND MOUNTING THE SECTIONS

A Spencer sliding microtome was used for cutting the sections. A blend of 40 parts polyethylene (low molecular weight) and 60 parts microcrystalline wax was used for embedding the sample. A block of white pine was cut and soaked in melted embedding medium for several hours. This process was necessary to replace the air so that air bubbles were not formed in the embedded sample. This treated block was cooled and clamped in the microtome so that the grain of the wood was diagonal to the knife edge. The wooden block was shaved flat by the knife in the microtome. A thin layer of water-soluble glue was spread on this flat surface and a sample of newsprint was pressed lightly, wire side up, onto the surface. The paper sample was oriented with the machine direction diagonal to the knife edge. After the glue dried, an infrared heat lamp was positioned above the sample to dry it and warm it for embedding. A few drops of melted embedding medium were put on the sample and the heat lamp was adjusted to keep it melted for a few minutes until the sample was impregnated. The microtome was allowed to cool to equilibrium. The stage was lowered until the knife just cleared the embedded sample. Cuts were made at 2-mu intervals until the surface of the paper was reached. The depth was set at the thickness desired, in this case 12 mu. The sections had a tendency to curl while they were being cut. Thicker sections curled more than thin ones. Once the sections had curled, they could not usually be flattened without disrupting the fibers. The method used to prevent curling consisted of placing a piece of silicone-treated lens tissue on the surface and very slightly moistening it to hold it in place. If the tissue was too moist, the section adhered to the knife and was broken. If the tissue was too dry, it fell off

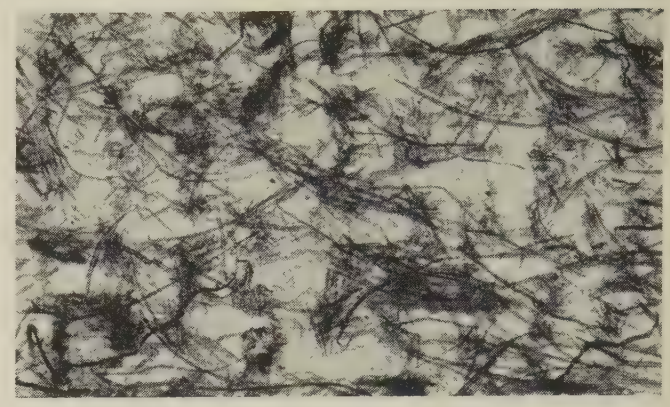

Fig. 1. 30-mu section from wire side of sample A. (10×)

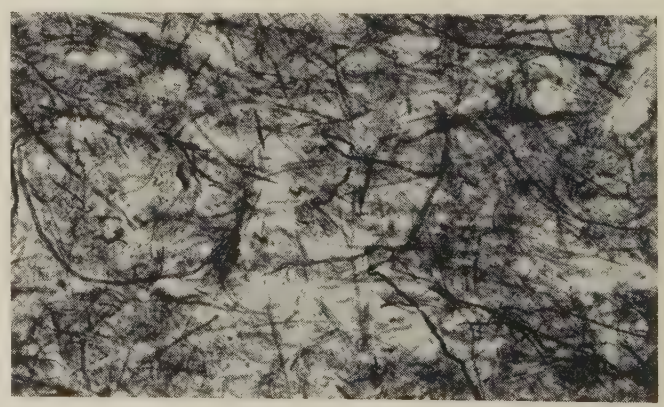

Fig. 2. 30-mu section from center of sample A. (10×)

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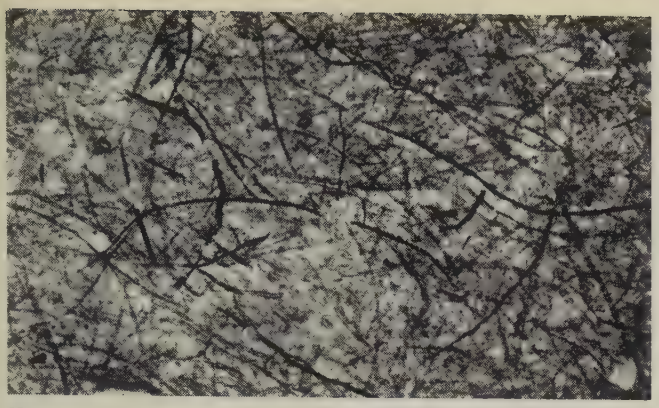

Fig. 3. 30-mu section from felt side of sample A. (10×)

the section and the section curled. After a little practice in judging the correct amount of moistening, good whole sections were obtained that did not curl. After drying, the tissue was easily removed leaving a flat whole section.

Fig. 4. 12-mu section from wire side of sample A. (10×)

The sections were mounted on microscope slides. Clean microscope slides were smeared with a very thin layer of Mayer's adhesives and a drop of water put on. The sections were placed on the treated slides and the slides were warmed gently to flatten the sections. The sections were pressed onto the slides with a blotter to

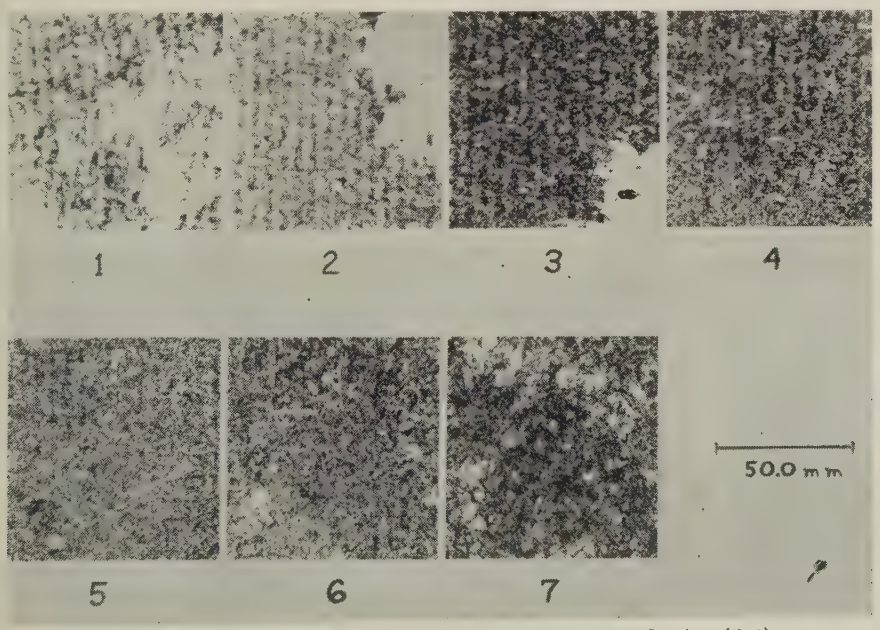

Fig. 7. Seven serial 12-mu sections from sample A. (4×)

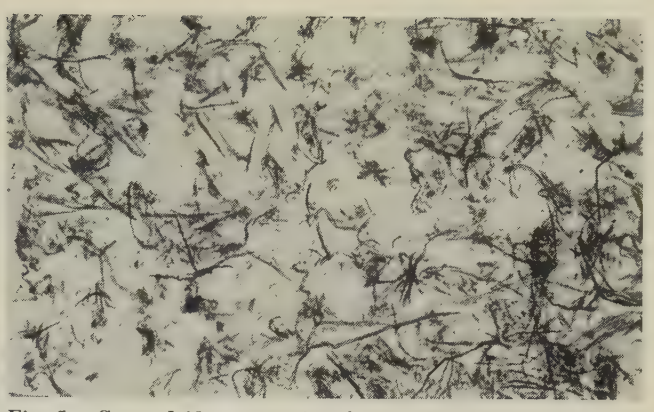

Fig. 5. Second 12-mu section from wire side of sample A. (10×)

remove the excess water and cement them in place (*4*). After drying, the embedding medium was removed from the sections by placing the slides in hot xylene. After the embedding medium was dissolved, the slides were

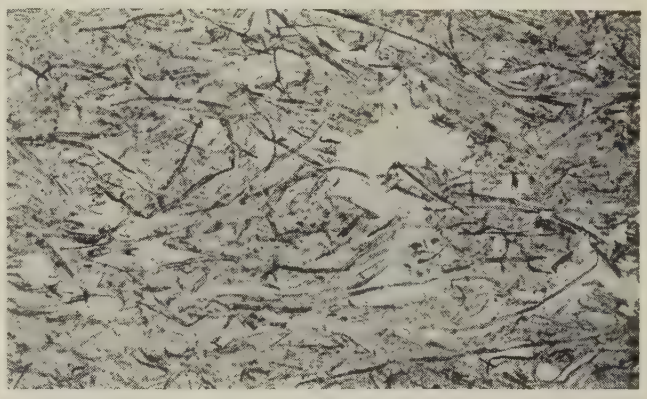

Fig. 6. Second 12-mu section from wire side of sample B. (10×)

put in absolute alcohol to remove the xylene. Next, the slides were put in water in replace the alcohol. The sections were then stained from an aqueous solution of methylene blue. An 0.5% solution was applied and left on for 1 min. The excess stain was then removed by washing several times with water. The sections were then dehydrated by placing them in absolute alcohol. Next, the sections were cleared in xylene. A drop of Canada balsam was put on each section and a cover glass was applied. Thus, permanent mounts were obtained of each section.

EXAMINATION OF PARALLEL SECTIONS

Both our own corporation's samples and competitors samples were sectioned to gain information about sheet structure. These samples will be referred to as A, B, and C. Sample A shows a severe wire mark while

samples B and C have a slight wire mark. Samples A and C have good formation while sample B has poor formation.

The longer chemical fibers were cut too short in the 12-mu sections to show their location and orientation. In order to see the orientation of these long fibers, 30-mu sections were cut, dividing the sheet into three equal parts. These thicker sections showed the orientation of the longer fibers quite well at the three levels in the sheet. Figures 1 to 3 show successive 30-mu sections through sample A which has a severe wire mark. Note the interlacing of the long fibers in Fig. 1. These correspond to the long fibers formed against the wire. Figure 2 shows the center 30-mu section and Fig. 3 shows the 30-mu section formed against the felt.

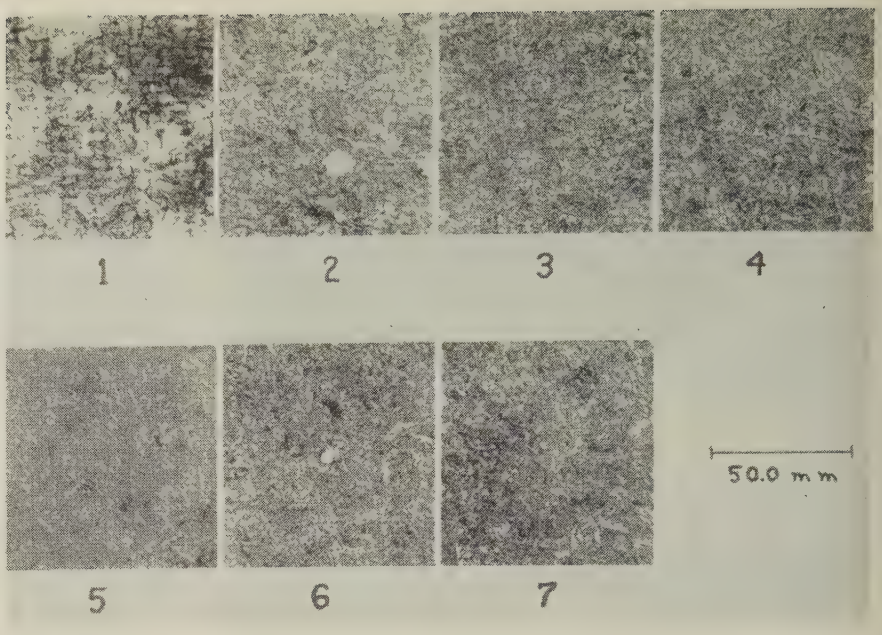

Fig. 8. Seven serial 12-mu sections from sample B. (4×)

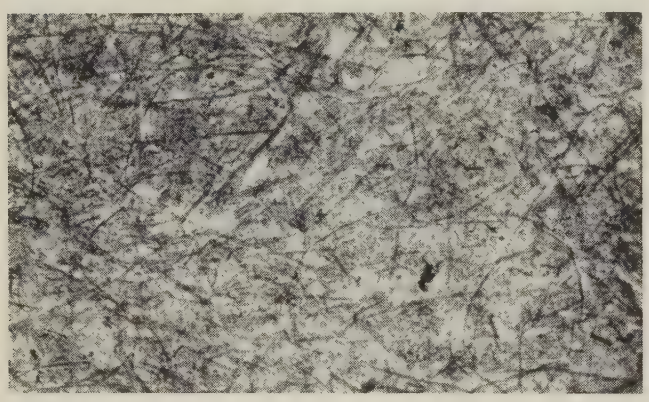

Fig. 9. 12-mu section on felt side of sample A. (10×)

Certain characteristics were found in the 12-mu sections that gave valuable information. Figure 4 shows the first section of sample A, comprised of the high points protruding into the open areas of the wire. Large amounts of short groundwood fibers are seen in this section. The sulphite fibers were cut too short to make a comparison of relative amounts of groundwood and sulphite.

The second section was always the most difficult to obtain, regardless of the degree of wire mark. This suggested that the region of the greatest interlacing of long fibers as seen in the 30-mu section was in this second section. Figures 5 and 6 show the interlacing of fibers to some extent although these long fibers are quite cut up.

The difference in degree of wire mark can be seen by comparing the successive sections of samples A and B. This wire mark can be seen better at lower magnification. In sample A (Fig. 7), the wire mark can be seen in the first five sections while in sample B (Fig. 8), it can be seen in the first section only. Other sheets sectioned showed the wire mark as far as the second, third, or fourth section.

The last successive section, or the layer immediately against the felt often contained a large number of very long fibers. These fibers were not found in all samples and appeared to be more indicative of good formation than of any degree of wire mark. When the length of these fibers was compared to the thickness of the section, the fact was realized that these fibers were extremely parallel to the surface. Figures 9, 10, and 11 show this seventh section. Samples A and C show these long fibers but B does not. Although A had a severe

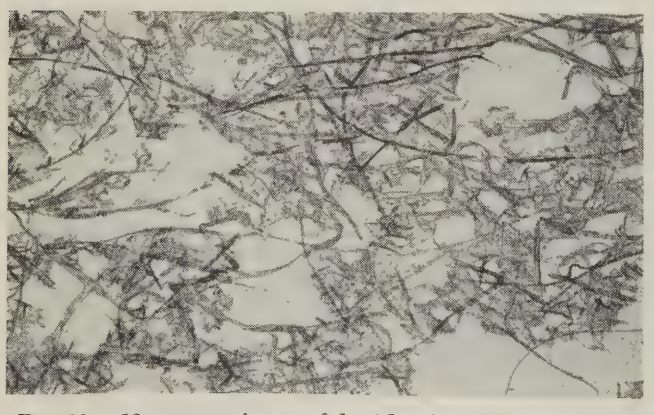

Fig. 10. 12-mu section on felt side of sample B. (10×)

Fig. 11. 12-mu section on felt side of sample C. (10×)

wire mark and C did not, the formation of both samples was much better than B, which did not show these long fibers.

While this technique was developed for newsprint, it could well be applied to other grades. Thicker or thinner sections could be cut with little variation in technique. Sections as thin as 8 mu were cut from newsprint, but 12-mu sections were easier to obtain and were sufficiently thin for this work.

This technique should be useful whenever sections are desired that cover a large area. High magnification as well as low can be used but high magnification does not take advantage of the larger areas than can be obtained. Penetration of coatings and distribution of fillers could be seen with these sections. All that is required is an embedding medium of the correct texture and hardness to hold the constituents in place while the sections are being cut. Many other uses could be made of parallel sectioning techniques. Along with recent developments in microscopy, this technique should be a valuable tool for obtaining a better understanding about the structure of paper.

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Alkaline Extraction of Spruce Pulps

KYLE WARD, JR., and MAIJA L. MURRAY

A comparison has been made of the efficacy of sodium and potassium hydroxide and of the corresponding borates in the extraction of the nonglucose polysaccharides from holocelluloses prepared from sprucewood and spruce pulps. Sodium hydroxide removes these polysaccharides more thoroughly than does potassium hydroxide. In general, there is little difference in the efficacy of the two borate solutions. Extraction with potassium hydroxide makes subsequent extraction with alkali borate less effective. For the isolation of specific fractions, however, successive extractions with potassium hydroxide and potassium borate solution should be very effective as is borne out by recent work of Jones, Merler, and Wise.

Complete removal of mannose and xylose residues from wood pulps by extraction procedures is difficult and has been reported by only a few investigators (*1–7*). Even the fractionation of cellulose derivatives prepared from wood to give exclusively glucan fractions is not easy (*8*). It is the more usual case that purified pulps (*9–19*) or fractionated materials (*20–22*) contain varying amounts of these nonglucose sugars. In particular, it is difficult to remove mannose from softwoods, such as spruce. The liquids usually used for extraction are solutions of sodium or potassium hydroxide. Recently, the addition of potassium metaborate to the latter has shown promising results (*12, 13*).

The present work is a comparison of sodium and potassium hydroxide, both with and without the addition of borate, as to their efficacy in removing mannose and xylose residues from holocelluloses of sprucewood and spruce pulps. Although previous work has shown potassium hydroxide to be a better extracting medium than sodium hydroxide for birch cellulosic pulps (*23*), the reverse seems true with spruce. These results on spruce agree with those of Hamilton and Quimby (*11*) on western hemlock and there may be a difference in this respect between hardwoods and softwoods.

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EXPERIMENTAL

Raw Materials

The materials used in this study are designated S_1, S_2, S_3, S_4, and S_5 and consisted of the following:

S_1 Sprucewood chips
S_2 Unbleached sulphite pulp (from S_1)—permanganate number 12.8
S_3 Unbleached sulphite pulp (from S_1)—permanganate number 14.0
S_4 Sprucewood chips
S_5 Unbleached kraft (from S_4)

Samples were ground in the Wiley mill (mesh no. 40), then extracted in Soxhlet extractors with ethanol: benzene (1:2) solution for 6 hr., followed by a 6-hr. 95% ethanol extraction.

The air-dried samples were chlorited according to the method of Wise (*24*). Three-hour chloriting seemed to be sufficient for the pulp samples. The wood chips were still yellow and were submitted to two more chloritings after which almost white materials were obtained. The approximate yield for pulps was 93%, for chips 70%.

Sugar Determination

The Forest Products Laboratory method of hydrolysis (*25*) was followed throughout this work. Three-hundred milligram samples were hydrolyzed with 3.0 ml. of 72% H_2SO_4 for 1 hr. at 30°C., then diluted with 84 ml. of water and autoclaved (at 15-lb. pressure) for 1 hr. After cooling, the solutions were stirred with about 25 g. of freshly washed Amberlite ion-exchange resin. IR-4B was used for the potassium hydroxide and potassium borate extractions. Color formation was occasionally noticed, however, and with the later work on sodium hydroxide and borate extractions, IR-45(in the carbonate form) was used. In about 30 to 40 min. a pH of 3.8 to 4.0 was reached. For all wood chip samples and also most pulp samples, a slight precipitation was noticed after the secondary hydrolysis. Filtration after resin treatment gave clear solutions that

Table I. Recoveries of Known Sugars

	a	b		a	b		a	b	c	d
Glucose, 210 mg.	185	200	Glucose, 240 mg.	205	245	Glucose, 270 mg.	235	165	300	260
	205	200		280	245		260	195	300	260
Av.	195	200	Av.	243	245	Av.	248	180[a]	300	260
Mannose, 45 mg.	43.0	51.0	Mannose, 30 mg.	30.0	25.5	Mannose, 15 mg.	16.3	14.3	14.3	15.0
	55.0	51.0		32.0	31.0		16.6	16.7	16.0	
Av.	49.0	51.0	Av.	31.0	28.3	Av.	16.5	15.5	15.2	
Xylose, 45 mg.	41.0	47.0	Xylose, 30 mg.	27.0	32.0	Xylose, 15 mg.	14.0	14.3	12.7	15.9
	51.0	47.0		29.5	31.0		15.0	14.7	17.0	
Av.	46.0	47.0	Av.	28.3	31.5	Av.	14.5	14.5	14.9	

[a] This low result is believed to be due to loss in handling.

were concentrated *in vacuo* to less than 10 ml. and diluted up to 10 ml. in volumetric flasks.

The hydrolyzates were spotted on Whatman no. 1 paper, usually immediately after hydrolysis. Occasionally samples could not be spotted at once and were kept for a day or two at 5°C. before spotting. In these cases a few brownish flakes were sometimes formed at the bottom of the volumetric flask.

A quantitative estimation of the sugar ratio was made by Pridham's method (*26*) using butanol:pyridine:water (10:3:3) developer (48 hr.) and *p*-anisidine hydrochloride spray. For the work with sodium extractions, the *p*-anisidine hydrochloride was replaced by aniline-hydrogen phthalate. This gave smaller blanks and more stable color solutions (*22*).

Separate chromatograms for estimating glucose and for mannose and xylose estimation were necessary on account of the small quantities of mannose and xylose in the hydrolyzates. In the case of glucose chromatograms, 1 ml. of the hydrolyzate was pipetted from the 10-ml. volumetric flask and diluted to 10 ml. in another volumetric flask.

Using the hydrolyzate of sample S_2, a good check of the sugar ratio was obtained when the analysis was performed by two different people.

	Operator A results	*Operator B results*
Glucose	268.0 mg.—91.5%	246.5 mg.—91.5%
Mannose	14.5 mg.—4.9%	13.5 mg.—5.0%
Xylose	10.5 mg.—3.6%	9.5 mg.—3.5%
	293.0 mg.	269.5 mg.

Table I shows the recoveries from three mixtures of known amounts of standard sugars and will give a measure of the accuracy of the method.

The data in Table I are reported in pairs, each of which consists of duplicate spots on the same chromatogram. Sugar solutions were made up fresh for chromatogram a, b, and d; chromatogram c was spotted a couple of days later but using the same solution as for chromatogram b. The mixtures in Table I represent 5 to 15% mannose and xylose contents. The recoveries for smaller amounts (0.5 to 1%) have been given by Matsuzaki and Ward (*22*).

Sugar ratios tabulated in Tables II, III, and V represent the averages obtained from two or three separate spots on each chromatogram.

Designations a and b in Table II represent separate hydrolyses of the various samples. In each case, b was run several weeks after a, but the results are still within the limits of the accuracy of the method.

Table II. Sugar Ratio in Chlorite Holocellulose from Samples S_1–S_5

	S_1	S_2		S_3		S_4		S_5	
		a	b	a	b	a	b	a	b
Glucose	73.1	91.5	90.6	92.7	90.6	71.6	72.8	87.4	86.5
Mannose	18.3	4.9	5.6	4.7	6.1	17.5	17.4	5.8	6.4
Xylose	8.6	3.6	3.8	2.6	3.3	10.9	9.8	6.8	7.1

Extraction of Holocellulose

All extractions were carried out under nitrogen at room temperature using mechanical stirring. The potassium hydroxide extraction sequence consisted of 24 hr. with 16.7% KOH, followed by three extractions for 24 hr. with 10% KOH. In two cases, a fifth extraction for 18 hr. with 10% KOH was given. The sodium hydroxide extractions were similar, except that the corresponding concentrations were 12.0 and 7.1% NaOH. The solutions for the borate extraction contained 9% boric acid and 16% KOH (or 11.4% NaOH). The sequence of borate extractions was 2-hr., 2-hr., and 24-hr.

Alkali extractions were made on 20-g. samples at 2% consistency. After each of the earlier extractions, approximately 1 g. of residue was removed, neutralized with dilute acetic acid, washed thoroughly with water, and air-dried. The remainder was sucked dry on a Buchner and added to fresh solution for the next extraction. The one gram of air-dried material was dried 4 hr. in a 60° vacuum oven for analysis. In the case of the borate extractions, the material was not sampled for analysis until after all extractions were completed. The residue was purified as in the case of the material extracted by alkali alone. The filtrates from the

Table III. Sugar Ratio in Samples S_2–S_5 After Each Extraction

	1st extr.	*2nd extr.*	*3rd extr.*	*4th extr.*	*5th extr.*
			S_2		
Glucose	90.6	95.9	95.4	96.1	95.7	..
Mannose	5.6	3.9	4.4	3.8	4.1	..
Xylose	3.8	<0.5[a]	<0.5[a]	<0.5[a]	<0.5[a]	..
			S_3		
Glucose	90.6	94.5	94.6	94.6	94.8	..
Mannose	6.1	5.4	5.2	5.2	5.0	..
Xylose	3.3	<0.5[a]	<0.5[a]	<0.5[a]	<0.5[a]	..
			S_4		
Glucose	72.8	86.4	87.1	86.4	82.8	86.2
Mannose	17.4	13.0	11.1	12.4	16.3	13.3
Xylose	9.8	0.6	1.8	1.2	0.9	0.5
			S_5		
Glucose	86.5	92.9	93.2	93.9	94.4	94.7
Mannose	6.4	5.9	6.0	4.8	4.3	4.5
Xylose	7.1	1.2	0.8	1.3	1.3	0.8

[a] Amounts too small to determine accurately with spectrophotometer.

Table IV. Sugar Ratio of Extracted Holocelluloses

Sample		A Holocellulose	B —A after exhaustive alkali extraction— KOH	B —A after exhaustive alkali extraction— NaOH	C —B after borate extraction— KOH	C —B after borate extraction— NaOH	D —A after borate extraction— KOH	D —A after borate extraction— NaOH
S_1	Glucose	73.1	..	92.2	..	94.2	89.8	96.6
	Mannose	18.3	..	6.9	..	5.5	8.9	2.8
	Xylose	8.6	..	0.9	..	0.3	1.3	0.6
S_2	Glucose	90.6	95.7	99.4	97.8	..	98.4	97.8
	Mannose	5.6	4.1	0.6	1.9	..	0.7	1.3
	Xylose	3.8	<0.5	<0.5	<0.5	..	0.9	0.9
S_3	Glucose	90.6	94.8	99.6	97.8	..	98.8	98.4
	Mannose	6.1	5.0	<0.5	1.1	..	0.7	0.7
	Xylose	3.3	<0.5	<0.5	1.1	..	0.5	0.9
S_4	Glucose	72.8	86.1	98.8	92.6	..	97.4	97.1
	Mannose	17.4	13.4	1.2	7.1	..	2.1	2.3
	Xylose	9.8	0.5	<0.5	<0.5	..	0.5	0.6
S_5	Glucose	86.5	94.7	98.5	95.7	..	96.6	97.0
	Mannose	6.4	4.5	0.9	3.5	..	1.7	1.5
	Xylose	7.1	0.8	0.6	0.8	..	1.7	1.5

potassium borate extractions were worked up by acidifying with excess acetic acid and pouring into three volumes of 95% ethanol. Precipitates were washed with cold 87% ethanol, hot 95% ethanol, hot absolute ethanol, hot methanol, and finally with ether. They were first air-dried and then dried *in vacuo* at 60°C. for 4 hr.

RESULTS AND DISCUSSION

Only in the case of extraction with potassium hydroxide was the extracted material analyzed after each extraction period, for the results there showed that only the first extraction produced much change. This is shown in Table III.

The ratio of sugars in the residue at the end of the extraction sequence has therefore been taken as a measure of the extraction. Table IV gives the results of the present study. The percentages are based on the sugars in the hydrolyzate. Even less nonglucose sugars remain on the basis of the original wood.

The results in Table IV show clearly that sodium hydroxide extracts more mannans from either sprucewood or pulp holocellulose than does potassium hydroxide. This is in accord with the results of Hamilton and Quimby (*11*). In fact, exhaustive extraction with sodium hydroxide of four of the five holocelluloses removed more mannose than did extractions with alkaline borate. Xylose is removed except for very small residual amounts by all the extractions. In general, sodium and potassium borates were equally efficacious, except on one wood holocellulose.

As would be expected, the pulping processes, especially the sulfite process, have made the removal of mannans easier. The kraft pulp, however, retained xylose more tenaciously than did the original wood.

Sodium hydroxide left so few nonglucose residues that a subsequent sodium borate extraction seemed unnecessary. However, with potassium hydroxide, a subsequent borate extraction was given. The figures in Table V indicate that potassium hydroxide extraction actually decreases the extractable mannans and makes subsequent borate extractions less effective. The reason for this is not clear.

Only in the case of the potassium borate extraction were yields determined. In this case it will be noticed from Table V that all the hemicelluloses are not recovered by the precipitation and washing procedure used. The washing was difficult in these samples and in the third sample in the table it was obviously inadequate.

The product extracted with alkali or with alkali borate contains a good deal of material not hydrolyzable to simple sugars by acid. Therefore, a quantitative sugar ratio analysis was run only on hemicellulose extracted from samples S_4 and S_5 by 16.7% KOH. The results are given in Table VI.

The sample from S_4 showed faint spots corresponding to arabinose, galactose, ribose, and rhamnose. It will be noticed that xylose is predominant in these hemicelluloses, especially in that from the kraft pulp holocellulose (S_5). In this material (from S_5) also, the mannose-glucose ratio is extremely high, indicating some mannose compound other than the glucomannan known to exist in spruce (*27–29*).

Qualitative chromatograms indicated that samples extracted with alkali borate also had more xylose than mannose and less glucose, but samples extracted with alkali borate after previous exhaustive extraction with alkali had only faint xylose spots. This indicates a means of fractionating the hemicelluloses of spruce, and probably other pulps, for more exact study. The study of successive extractions with potassium and sodium hydroxides would also be of interest in this respect.

Table V. Yields of Fibrous Material and Hemicellulose After Alkali Borate Extractions

Material used for borate extraction		Fibrous material recovered, %	Hemicellulose obtained, %
No previous alkali extraction	S_1	56.0	30.0
No previous alkali extraction	S_2	82.0	11.0
No previous alkali extraction	S_3	82.0	28.0
Extracted four times with KOH	S_2	90.0	5.0
Extracted four times with KOH	S_3	88.0	4.6
Extracted five times with KOH	S_4	88.0	6.4
Extracted five times with KOH	S_5	90.2	2.6

SUMMARY AND CONCLUSIONS

Holocelluloses from sprucewood chips, sulphite pulps,

Table VI. Sugar Ratio on Hemicelluloses Extracted with Potassium Hydroxide

	S_4	S_5
Glucose	10.0	3.7
Mannose	44.4	30.3
Xylose	45.6	66.0

and kraft pulp were extracted with sodium and potassium hydroxide and with the corresponding borates. Determination of the constituent sugars before and after extraction shows that sodium hydroxide removes the nonglucoses more thoroughly than any of the other extractants. In general, there is little difference in the efficacy of the two borates. Extraction with potassium hydroxide actually makes subsequent extraction with alkali borate less effective. For more complete removal of nonglucose sugars, therefore, the alkali borate treatment recommended by Jones, Wise, and Jappe (*13*) should preferably be applied without previous alkali treatments. For the study of specific fractions, such as the glucomannans in softwoods, however, the material extracted by potassium borate from holocelluloses previously extracted with potassium hydroxide should be extremely well suited, as it contains almost no xylose and none of the less frequently encountered sugars.

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Revision of the Dye Adsorption Technique for the Estimation of External Specific Surface

EDWARD F. THODE

The dye adsorption procedure for the estimation of external specific surface of pulp has been revised to improve the precision of results. Principal changes from the technique previously reported involve the use of specially purified dye, the substitution of a more rapid fiber separation procedure, the use of nonionic dispersant to stabilize the samples for spectrophotometric analysis and the application of a modified Brunauer-Emmett-Teller technique to the analysis of the data. Results of the evaluation of this revised technique in comparison with other surface area methods are presented in another paper. These results indicate in general that the dye adsorption method does provide a reasonable estimate of the comparative external specific surface of whole fibers, but is almost wholly insensitive to fines, when the dyestuff C.I. 29160 is used.

A REVIEW of the attempts to measure or estimate the external specific surface of fibers in a sheet or in a slurry reveals that chemical, as well as physical, methods often have been tried for such purpose. The possible advantages of chemical methods of a greater speed of determination and of a lesser need for specialized equipment have not been realized in the past or have been offset by other disadvantages. The surface catalytic method, for example, is a very slow and tedious determination requiring great manipulative skill on the part of the analyst. The dye adsorption method was originally proposed to fill this need for a rapid method which could be performed with ordinary laboratory equipment (*1*, *2*).

Although it has been demonstrated that the dye adsorption method is suitable only for estimation of *comparative* surface areas, it has been shown that the figures so obtained may be of use in correlating pulp properties as part of a pulp evaluation study (*3*). The method as previously used had, however, some experimental and computational uncertainties. In order to use this technique in connection with a comprehensive pulp evaluation study, it was decided to develop a completely revised dye adsorption method. This paper presents a brief survey of the background of the method, the reasons for revision of certain steps, a complete procedure for the method finally adopted, and a few comments on applications of this procedure or an abbreviated version thereof.

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BACKGROUND OF METHOD

The object of the dye adsorption procedure is to dye the surface only of pulp fibers in a uniform manner, so that the amount of dye consumed may be considered proportional to the specific external surface.

Summary of Procedure

Uncontaminated pulp fibers are dispersed in dyebaths of various low initial dye concentrations and at low

consistency for a limited period of time. A direct dye of very high molecular weight is used, only a very limited amount of electrolytic "assistant" is added, and room temperature is maintained so as to discourage penetration of the dye into the fiber or excessive aggregation of dye on the surface. At the end of the limited dyeing time, the fibers are separated from the spent dye liquor, the takeup of dye determined by analysis of the spent liquor, and the actual weight of fiber involved determined directly. The amount of dye taken up per gram of fiber at a given final dye concentration and the change in this figure with change in dye concentration gives an indication of the external specific surface of the fiber.

Mechanism

If the method were to be justified by adsorption theory, it would be necessary to establish that an equilibrium condition had been reached. It is patently impossible so to establish, although early work on the method seems to indicate that 10 min. dyeing time brings one close to the equilibrium point between dye at the *external surface* and in solution. Also, adsorption theory requires that it be assumed that the mechanism involves adsorption of the dye on active sites (on the fiber surface) as a monolayer, then multilayers, of single molecules. It is certain, however, that the dye used does not, in fact, exist as single molecules in aqueous solution at room temperature. One of two mechanisms must be involved; either the aggregates of dye take up on the fibers as such, or there is an equilibrium in the solution between aggregates and single molecules permitting single molecules to adsorb on the fibers, with others dissolving from aggregates taking their place. There is no convincing evidence favoring either one of these views over the other, but the author is inclined to favor the latter. The theoretical deficiencies just outlined do not, however, preclude empirical application of adsorption relations to the dye adsorption data.

Purity of Pulp

To prevent excessive aggregation of the dye in the dyeing solution, the electrolyte content is purposely kept very low (0.002*M* KCl). Apparently, however, there must be some bound metal ion in the pulp if the activation energy barrier for dyeing is to be low enough. An ash content of 0.2% seems to suffice. Excess electrolyte from pulp purification operations must be washed out, again lest dye aggregation be too great.

REVISION CONSIDERATIONS

Purity of Dye

In all previous experiments, Benzo Fast Scarlet 4BSA (C.I. 29160) dye was obtained in the unloaded or unreduced state (i.e., before addition of salt for standardization) and used without further purification. It was known that a certain amount of salt from the crystallization step was included, but its effect was thought to be negligible. For the present work the dye was purified by forming the di-ortho tolyl guanidine salt of the dye used and, after filtering, washing, and drying, regenerating the potassium salt of the dye with potassium hydroxide from methanol solution of the DOTG salt. Dye so purified gave more consistent results than unpurified dye.

Aggregation of Dye

During the course of previous experiments it was suspected that the dye was aggregated in solution at the concentrations used, but no adverse influence on the accuracy of the spectrophotometric analysis could be definitely established. In this investigation, however, reproducible analytical results were very difficult to obtain until a technique of stabilizing the solution for analysis was adopted. All samples for analysis were diluted with a 0.6% solution of Brij 35 (Atlas Powder Co. polyoxyethylene lauryl alcohol). (This material was chosen from among a number of nonionic detergents as having, experimentally, the maximum dispersing effect on the dye used.) After adoption of this step, determination of concentration could be made with an average deviation of ±0.0001 g.p.l.

Analysis of Data

In order to obtain a number for comparison of one pulp with another, various means of analyzing the actual dye takeup data have been employed. Originally, isotherms were obtained by plotting dye adsorption as a function of final concentration of dyebath and estimating the point of monolayer adsorption from the contour of the isotherm. This often proved difficult, however. Later, plots of specific initial concentration as a function of specific final concentration were prepared. The upper portion of such curves are straight lines which may be extrapolated to intercept the y-axis to obtain a value of specific dye adsorption. This method is likewise subject to considerable error and has been abandoned as unsatisfactory.

It had been thought for some time that the most accurate method of determining monolayer adsorption would be the application of the Brunauer-Emmett-Teller (BET) adsorption equation (*4*) in form suitable for adsorption of solute from solution. The main objection to such application was that a term for saturation concentration must be employed, and there was no way of knowing what the proper value of such term should be for this system. The solubility should logically be such saturation concentration were it not for the tendency of the solution to aggregate. In spite of the theoretical uncertainty, it was decided for the purpose of the current work to attempt an empirical fit of the BET equation to the dye adsorption data. This was accordingly done for various values of C_o, the "saturation concentration." It was found that the experimental data showed good conformity to a straight line when a value of C_o of 0.24 g.p.l. was used. The value of the monolayer so calculated agreed well with other methods but appeared to be obtainable with greater precision. The BET analysis was therefore adopted for the purpose of this project.

DETAILS OF REVISED PROCEDURE

I. Pulp Preparation

Suspend 8 g. (oven-dry basis) of disintegrated wet pulp in deionized water at about 0.5% consistency. About 10 min. stirring with a glass propeller is usually

required for good dispersion. Filter on qualitative filter paper (such as Cenco 13255) in a Buchner funnel. Wash four times with deionized water, allowing a 10-min. soaking period before filtering off each batch with wash water.

Quantitatively transfer the washed fiber to a clean beaker and disperse it in deionized water at 1.0% consistency.

II. Dye Preparation

(*Note:* The dyestuff used for this work is listed in the Color Index as C.I. Direct Red 23 with new series index number C.I. 29160.)

Prepare from stock solution of the purified dye, a working solution of a concentration of about 0.16 g.p.l. and determine this concentration to 0.001 g.p.l.

III. Glassware

At the beginning of a run the following must be available:

250-ml. beakers (3). Clean, dry, tared.
25 by 40 weighing tubes (8). Clean, tared.
Fritted glass crucibles, coarse (8). Clean, dry, tared.
Pyrex test tubes and stoppers, 18 by 150 mm. (8). Clean, dry.
125-ml. filter flask (2). Clean, dry.
Gooch crucible.
Small dipper, marked at 40 ml.
Pipets.

IV. Dyeing Technique

A. Dip out 40 ml. of pulp slurry and transfer to a 250-ml. beaker. Add 10 ml. 0.02 *N* KCl solution. Place beaker on triple beam balance and add deionized water to such weight that after addition of dye there will be exactly 100 g. water in the bath [e.g., if 5 ml. dye solution is to be added (first point), 95 g. water should be present before dye addition].

B. Stir without splashing for 2 or 3 min.

C. Add specified amount of dye (5 ml. for first point), starting clock when dye first starts to flow in from pipet. Stir continuously but gently.

D. At 9 min. on the clock, stop stirrer, remove beaker from stirring position and commence with E as expeditiously as possible.

(*Alternative I.*—For all pulps of high drainage rate.)

E. Swirling the beaker contents gently, pour one-quarter to one-third of the contents into a Gooch crucible, applying gentle suction only after crucible is filled. After a good mat has formed, transfer the Gooch crucible to a clean, dry flask (flask II) and as rapidly as possible filter off the remaining dye bath. Pour a portion of the fiber-free filtrate from flask II into a clean, dry test tube labeled with run no. and sample no.

F. Rinse the contents of flask I and the fiber clinging to the stirrer into the beaker and then rinse all such fiber-bearing liquid into the Gooch crucible.

G. Quantitatively transfer the fiber from the Gooch crucible to a tared weighing tube.

(*Alternative II.*—For all slow pulps.)

E. As rapidly as possible transfer the beaker contents to two dry 100-ml. centrifuge bottles and immediately centrifuge at 3300 r.p.m. (2000 g.) for 2 min. Use caution in braking centrifuge, or merely allow to coast to a stop, to prevent swirling and redispersion of the fibers. If redispersion occurs to a noticeable extent, the run is invalid.

F. Carefully decant the *supernatant* liquor from the bottles through a coarse, tared, fritted-glass crucible. Retain this original filtered material for analysis.

G. Transfer the wet pad of centrifuged fiber in the bottles to a weighing tube and dry. Scavenge fibers from the bottles, stirrer and beaker by rinsing and collect them on fritted-glass crucible. Likewise dry this glass crucible and weigh both weighing tube and crucible to obtain total weight of fiber.

(End of alternative schemes.)

H. Repeat steps A–G seven times, increasing the amount of dye used by 5 ml. each time.

V. Analysis for Final Dye Concentration

[*Note:* All dilutions for spectrophotometric determinations should be made with a 0.6% solution of Brij 35 (polyoxyethylene lauryl alcohol, Atlas Powder Co.)].

1. By volumetric technique, prepare a solution $^1/_{10}$ the concentration of the working solution, using pure water as diluent. Then dilute this solution 1:1 with Brij 35 solution. This is the blank.

2. Dilute a portion of each of the samples in the test tubes with Brij 35 solution as follows: samples 1, 2, 3, 1:1; samples 4, 5, 6, 1:2; samples 7 and 8, 1:3. Use precise volumetric technique. Thermostating is unnecessary but all solutions must be at room temperature.

3. Determine optical densities (o.d.) of the blank and of the diluted samples as compared with pure water using the Beckman DU spectrophotometer at 506 mmu wavelength (and also at 586 mmu if suspended fines are present). Employ the highest sensitivity consistent with reasonable instrument stability. For samples 5 through 8 also determine the optical density as compared with the blank. Since o.d.'s are additive, the o.d. referred to water may be checked by adding the o.d. of the blank to that of the unknown as compared with the blank.

4. These solutions appear to obey the Beer-Lambert law when Brij 35 is present. Thus, since the concentration of the blank is known, concentrations of unknown samples may be determined from a simple

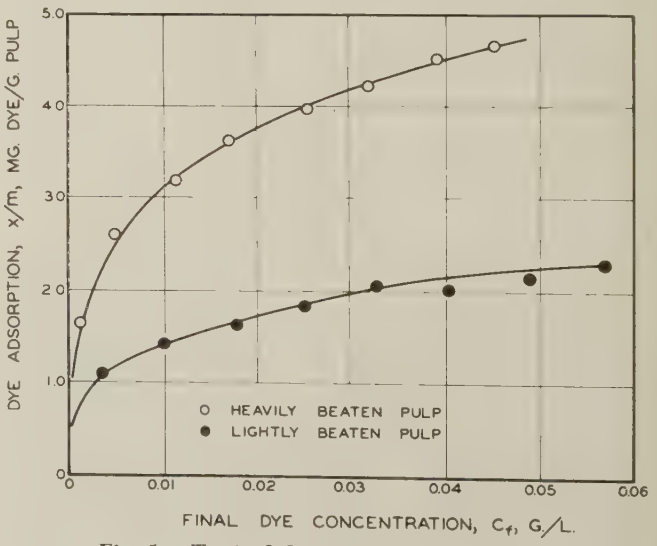

Fig. 1. Typical dye adsorption isotherms

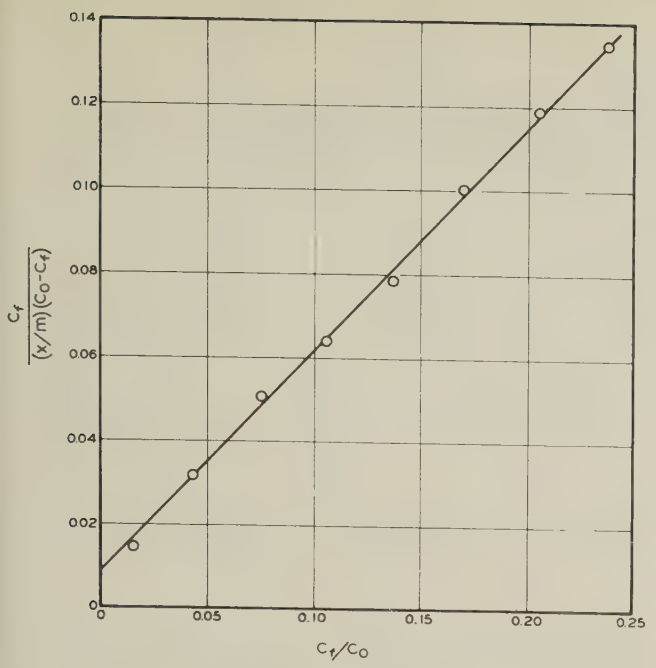

Fig. 2. Typical BET plot (data for lightly beaten pulp, lower curve of Fig. 1)

proportion of the o.d.'s. If fiber debris is present, o.d. figures at 586 mmu (minimum absorption) should be used to compute the fines correction.

VI. Weight of Fiber

The weighing tubes (and crucibles) containing the fiber pads should be dried overnight at 105°C. and the dry weight of the fiber (m) determined.

VII. Computation

For computation of the specific dye adsorption (S) of the fiber it is necessary to determine the milligrams of dye adsorbed per gram of dry fiber (x/m) for each sample. x is obtained by subtracting the final concentration C_f (g.p.l.) from the initial concentration C_i and multiplying by 100. (See Fig. 1 for a plot of x/m versus C_f.)

These data are then used to compute a Brunauer-Emmett-Teller (BET) plot of the data, (see Fig. 2).

$$\frac{C_f/C_o - C_f}{x/m} \text{ vs. } C_f/C_o$$

(*Note:* As empirically determined, a value of 0.24 for C_o should be employed in the above computations.)

The intercept of the line so obtained is $1/SK$ and the slope of the line is $(K - 1)/SK$. Thus, from the values of these two functions, the constant K and the desired constant of the system S may readily be computed. S is related to the external specific surface of the particular fiber sample studied.

ABBREVIATED PROCEDURE

For routine comparison of pulp samples of not too widely differing characteristics, an abridged procedure may be adopted, as follows.

Follow the entire dyeing technique scheme, IV, A-G, but for only two samples instead of eight. These two samples should be run with the *same* initial concentration of dye, that concentration so chosen, by test or experience, to give a final dye concentration in the range of 0.028 to 0.032 g.p.l. The average value of x/m for these duplicate runs may be taken as proportional to S, the specific dye adsorption as usually computed in part VII.

DISCUSSION

Results obtained by use of this revised technique are reported in another paper. It is sufficient to comment here that the only new information about the applicability or limitations of the dye adsorption method is that this method, at least with the particular dyestuff presently employed (C.I. Direct Red 23), is extraordinarily insensitive to the presence of fines. Apparently, the increase in dye takeup on beating is directly related to the development of surface of whole fibers, by bruising, crushing, brooming, etc. The very large increase in external surface of the total pulp sample which arises from the creation of "fines" and fiber debris simply does not show up in the dye adsorption test which is outlined in this paper.

This situation may be an advantage or not, depending upon the use to which the information is to be put. If one wishes to correlate surface changes with physical tests such as tensile and burst, which depend on whole fiber surface, then the test is useful. If one is interested in properties such as tear or fold, or in machine drainage characteristics, the results of the dye adsorption test could be misleading. The qualified term, "could be," is employed because, under normal conditions, the development of fines surface is proportional to that of whole fiber surface, so that empirical correlations of dye adsorption values with the latter physical properties will often be valid.

For much development and evaluation research, the estimate of relative surface areas of whole fibers provided by the "Abbreviated Procedure" will be found to be satisfactorily precise. If such an estimate is needed, it is believed that this procedure is the most convenient and rapid suggested to date. The complete procedure (with its better precision) requires about the same laboratory and computation time as the more desirable filtration resistance method. It does not require the special apparatus, however, and thus may be found useful for certain research and development applications where investment in special apparatus cannot be justified by the results expected.

CONCLUSIONS

1. An improved technique for the determination of the specific dye adsorption of beaten and unbeaten wood pulp fibers has been developed.
2. This method apparently yields figures which are proportional to the area available for bonding of the whole fibers in the pulp. The method is insensitive to fines. It is not absolute.
3. The dye adsorption technique has utility where an estimate of comparative areas of pulp samples is desired.

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The Beater Addition of Phenolic Resins

N. G. LONG, S. E. CHURCH, and V. STANNETT

The results of a study of the properties of paper treated with phenolic resins by the "beater addition" technique are presented. Factors affecting the retention and the wet and dry strength of the sheets are discussed including the resin viscosity, the temperature of addition and the type and freeness of pulp. The results obtained with oven cure and infrared cure are presented and it is shown that comparable results are obtained with both methods. Finally a method of measuring the retention of phenolic resins by using ultraviolet absorption of the white water is presented and its efficiency examined.

In recent years, a considerable amount of effort has been expended in studying wet-strength development by the beater addition of phenolics (*1–4*). This study can be regarded as an expansion of the work of Snyder (*1*) and Spivak and Moyer (*2*). It also extends the recent work of Marder (*3*) and is related to the findings of Marander, Krajewski, Hoffman, and Dalheim (*4*).

It has been repeatedly demonstrated (*3, 4*) that severe curing conditions of phenolic-treated papers are necessary to develop wet strengths that are comparable to papers treated similarly with other commercial wet-strength resins. Under their respective laboratory conditions, the above investigators have proposed that the poorer performance of phenolics in the beater was due also to poor retention and poor distribution. However, one of the difficulties in obtaining a complete picture of this resin's properties has been the lack of a reliable technique for measuring resin retention. The solvent extraction method of Bhargava, Hoffman, and Stannett (*5*) was applicable to large additions but proved to be unsatisfactory where 5%, or less, resin was combined with the pulp.

At the end of this paper, a method of determining resin retention by the ultraviolet absorption of the white water is briefly described. Extensive experimentation has shown the validity of the method, further details of which may be found elsewhere (*6*).

EXPERIMENTAL

This study was carried out principally with five single stages of water-soluble phenolic resins, as prepared by Synco Resins, Inc. Their properties are listed in Table I. The phenolic and urea resins were stored under normal refrigerator conditions to prevent undesired polymerization. The melamine-formaldehyde acid colloid was made up, according to the manufacturer's specifications, from powdered resin (*7*).

All of the major research was conducted with unbleached spruce kraft obtained from the Brown Co. This was beaten to a 570 ml. ± 10 Canadian Standard freeness, according to TAPPI Standard T 200. This pulp was then stored for not less than 4 days under paradichlorobenzene to prevent deterioration.

Table I. Experimental Resins

Resin	*Number*	*Viscosity, cp.*[a]	*Nonvolatile content, %*
Phenol formaldehyde	X 700A	39	50.5
	X 700B	117	52.8
	X 700C	880	51.9
	X 700D	4500	42.3
	X 700[b]	4700	45.7

[a] Refers to Brookfield viscosities at 25°C.
[b] Resin X 700 was greatly advanced over its original state and was used only on preliminary studies with bleached sulphite.

The resin additions were made to 1.57 ± 0.02% consistency pulp, which had been previously adjusted to the desired temperature. Both the phenolic and urea resins were diluted with equal parts of water prior to their addition. Sufficient dispersion was achieved with 1 to 2 min. agitation, whereupon the pH was lowered to 4.0 with a prepared concentrated alum solution. All handsheets were prepared and dried according to TAPPI Standard T 205, with the exception that the metal disk used normally in drying was replaced by two sheets of filter paper. This modification eliminated two-sidedness. Retentions were measured by nitrogen determination in the case of melamine and urea resins and by the ultraviolet absorption method with the phenolic resins.

All oven cures were made at 150°C. for 5 min. Radiant curing was performed on the same apparatus that Dalheim (*8*) used under his prescribed conditions for obtaining maximum strength properties. This involved passing the handsheets between two banks of two RADD Chromolox heaters at a distance of 2 in. from each for 1.5 sec.

RESULTS AND DISCUSSION

It was found that the resin retention would vary from 20 to 80% depending upon the following variables: resin molecular weight, the temperature of precipitation, and the per cent of resin added. Each was studied independently as follows: with a 5% addition precipitated at 20°C., near maximum retentions of 65 to 68% are obtained in the 1000 cp. range (Fig. 1). These data correspond to the development of optimum wet and dry burst and tensile strengths (Figs. 2 and 3). Wet burst and tensile strengths of 50 to 55% and 38 to 45%, respectively, have been achieved with these conditions, using an oven cure of 5 min. at 150°C

Retentions of 92% were obtained by removing the low molecular weight water solubles. However, as a result, both wet burst and wet tensile strengths decreased from 58 and 41%, respectively, to 33%. No other attempts were made to increase the retention efficiency since it appeared obvious that other factors would have to be relied upon in order to further develop the strength properties.

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Table II. Effect of Freeness Variation on Wet and Dry Burst and Tensile with 1 and 2% Additions of X 700C Precipitated at 20°C.

Freeness, ml. (unbleached kraft)	*Resin added, %*	*Resin content, %*	*Burst factor*			*Tensile, kg./15 mm.*		
			Dry	*Wet*	*% Wet strength*	*Dry*	*Wet*	*% Wet strength*
570	Control	...	61.2	...	...	7.85	...	...
	1	0.770	67.5	19.4	28.6	8.65	1.88	21.7
	2	1.30	80.8	44.2	54.8	10.30	3.31	32.2
300	Control	...	73.0	...	...	10.30	...	...
	1	0.746	87.6	30.4	34.6	10.6	2.76	26.0
	2	1.46	87.2	48.7	56.0	11.8	4.17	35.3

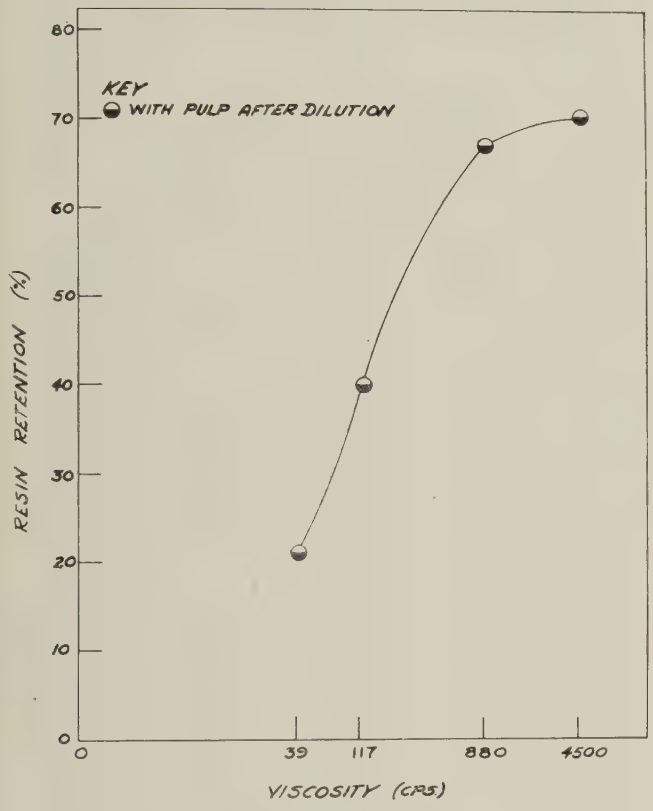

Fig. 1. Effect of molecular weight variation on retention using a 5% addition at 20°C.

The precipitation temperature appeared to govern, to a great extent, the physical characteristics and associated surface properties of the precipitated resin particles at any given molecular weight. As the temperature of the fiber slurry was lowered from 40 to 0°C., the retention increased (Fig. 4), because of the decreased resin solubility. As was expected, the dry burst and tensile followed a similar pattern. However, generally better wet burst and tensile strengths were developed at 40°C. No explanation can be offered at this time. With the highest molecular weight resin (X 700D), at 40°C., a pronounced decrease in the strength properties was noticed. This was attributed to a "pilling" affect, in addition to the decreased retention. Some preliminary investigations showed that this resin agglomerated at 40°C. and did not form the finely divided particles which were characteristic at lower temperatures. These experiments were run in distilled water, using alum to pH 4.0.

Figure 5 illustrates a typical retention versus strength curve obtained by varying the addition percentage. Presumably, the available bonding sites are filled rapidly. Thus, subsequent additions, which yield resin contents of 5% or more, produce less and less wet and dry strength improvement, as shown in Fig. 5, 6, 9, and 10. Substantial increases in wet and dry strength were observed at low resin contents. With a resin content of 1.3% of X 700C, the wet and dry burst

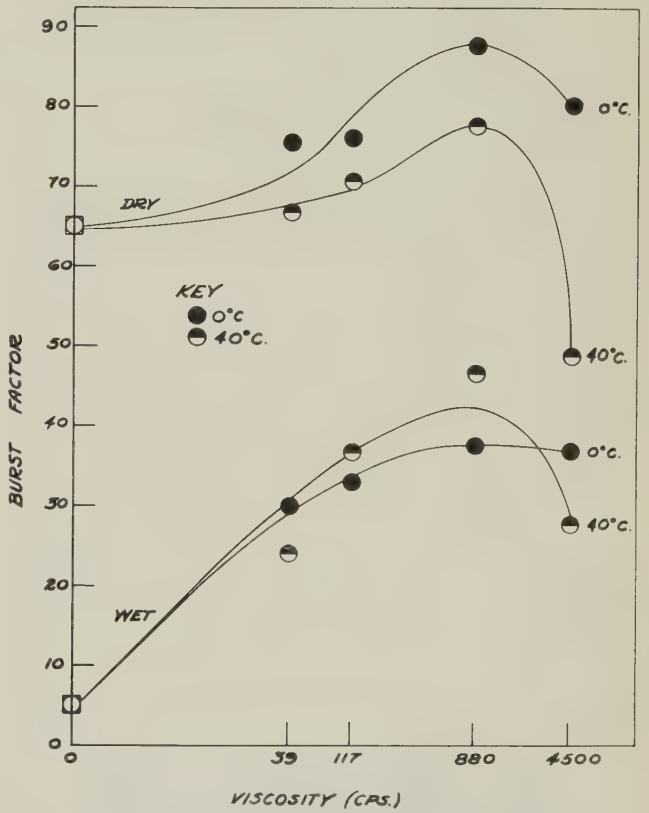

Fig. 2. Burst factor variation with viscosity at 0 and 40°C., of a 5% addition

Table III. Comparison of Bleached Sulphite and Unbleached Kraft Wet and Dry Burst and Tensile Strength Data
5% Addition, 20°C.; oven cure = 5 min. at 150°C.

Pulp	*Resin*	*Burst factor*			*Tensile, kg./15 mm.*		
		Dry	*Wet*	*% Wet strength*	*Dry*	*Wet*	*% Wet strength*
Bleached sulphite	Control	30.0	...	...	5.58	...	...
	X 700[a]	28.1	10.1	46.0	4.64	1.58	34.0
Unbleached kraft	Control	65.0	...	...	7.6	...	...
	X 700[b]	82.5	45.6	55.3	10.7	3.47	34.4

[a] Viscosity was 4700 cp.
[b] Viscosity was 4500 cp.

Table IV. Effect of Phenol, Urea, and Melamine-Formaldehyde on Wet and Dry Burst and Tensile Strength

Conditions: 30°C. addition, pH 4.0; cure: 5 min. at 150°C. (oven)

Resin	% Added	Burst factor			Tensile, kg./15 mm.			Retention, %	Resin content, %
		Dry	Wet	% Wet strength	Dry	Wet	% Wet strength		
Control	...	44.7	...	...	5.76	...	...	...	...
Phenolic[a]	0.5	49.9	15.0	30.1	5.90	1.70	28.8	51.1	0.26
Cationic urea	0.5	45.7	13.3	29.1	5.78	1.35	23.4	52.0	0.26
Melamine	0.5	55.9	18.1	32.4	6.55	1.71	26.1	100.0	0.50
Phenolic	2.0	59.0	28.0	47.5	7.40	2.38	32.2	67.6	1.35
Cationic urea	2.0	56.2	29.1	50.7	6.65	2.30	34.6	29.0	0.58
Melamine	2.0	67.0	31.8	47.4	7.79	2.34	30.1	100.0	2.00

[a] The resin viscosity was 950 cp.

factors increased 38.1 and 15.7 units, respectively. Handsheets containing 3.32% of X 700C showed increases in respective wet and dry burst factors of 45.7 and 25.7. It was very apparent that continued increases in resin content above 10% results in diminishing strength factors. The per cent retention of each molecular weight resin tended to rise slightly with increased addition rates. This could be attributed to increased resin entrapment by effective filtration. The variations on the tensile data correspond closely with the bursting strengths with the exception that the effects of resin were less, which was the trend throughout the study.

A photomicrograph of fibers containing 30% X 700C resin, which was precipitated at 30°C., is shown in Fig. 7. Under these conditions, the resin was retained as small crystallinelike particles and as larger irregularly shaped aggregates. Figure 8 illustrates some untreated fibers at the same magnification.

The curing power of infrared radiation was best exemplified by the X 700C resin, as shown by Figs. 9 and 10. With the exception of the dry burst, the the strength values were better than those obtained with the oven cure. It should be noted that the

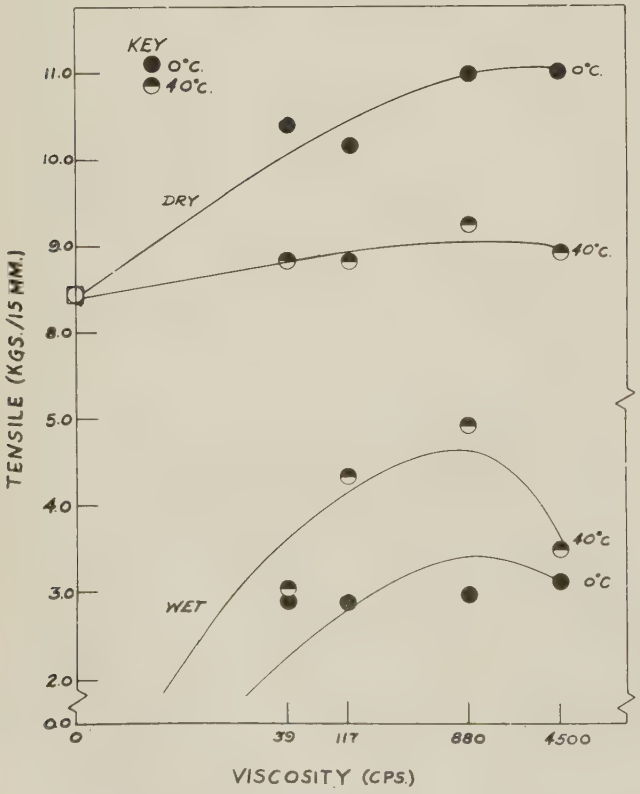

Fig. 3. Tensile variation with viscosity at 0 and 40°C., 5% addition

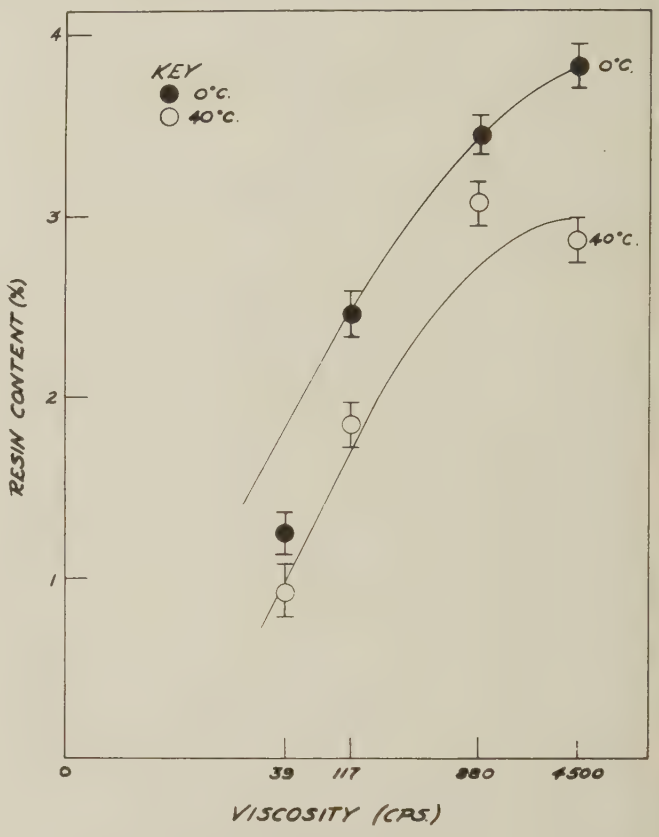

Fig. 4. Resin content variation with viscosity, 5% addition at 0 and 40°C.

strengths developed at the various resin contents were apparently more dependent upon the untreated dry strengths than the differential qualities of resin retained. Radiant heat curing conditions were found to be extremely critical since degradation can easily result. This might have occurred with the above mentioned dry burst. Therefore, since such comparable results were obtained, the short curing cycle would appear most advantageous from the practical viewpoint of the papermaker.

When the freeness was lowered from 570 to 300, little

Table V. Sample Calculation Data

5% of X 700D at 0°C.

Case	Value
Weight total resin input, g.	1.9625
Volume stock slurry, cc.	13,100
Optical density of white water[a]	0.074
Concentration of white water, ppm.[b]	35
Weight resin in white water[c]	0.459
Resin in white water, %[d]	23.4
Retention, %[e]	76.6

[a] Average of two separate samples (0.075 and 0.073).
[b] Value obtained from Beer's Law curve.
[c] Weight resin = concentration (p.p.m.) × total vol. (cc.) = (35)(13,100).
[d] % Resin in white water = 0.0459/1.9625.
[e] % Retention = 100 − (0.0459/1.9625) × 100.

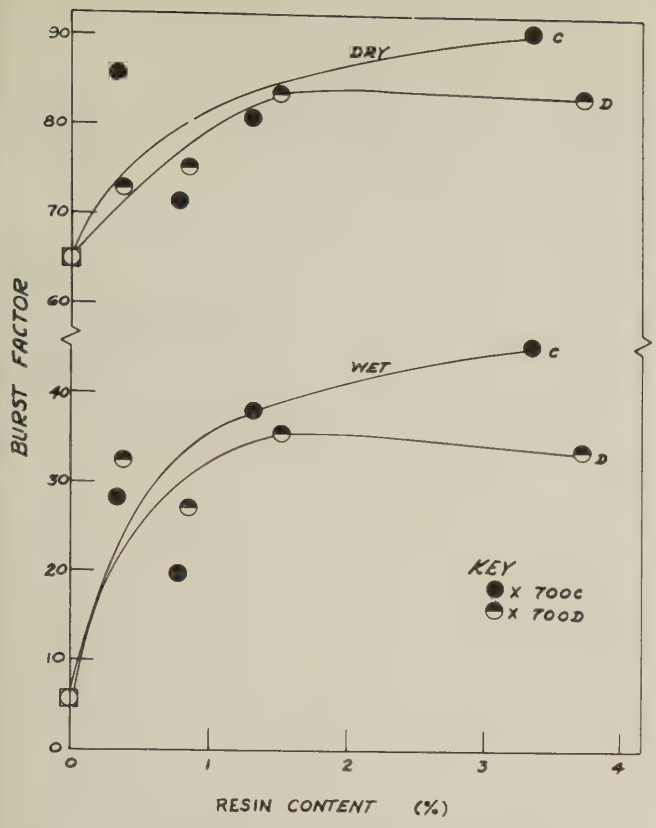

Fig. 5. Burst factor variation with resin content, 20°C., oven cure: 5 min. at 150°C.

or no retention increase was noted, indicating that the retention, in this case, is controlled more by the resin than the pulp. However, by developing more potential bonding sites through beating, the retained resin was more efficiently utilized. This, as was indicated by the

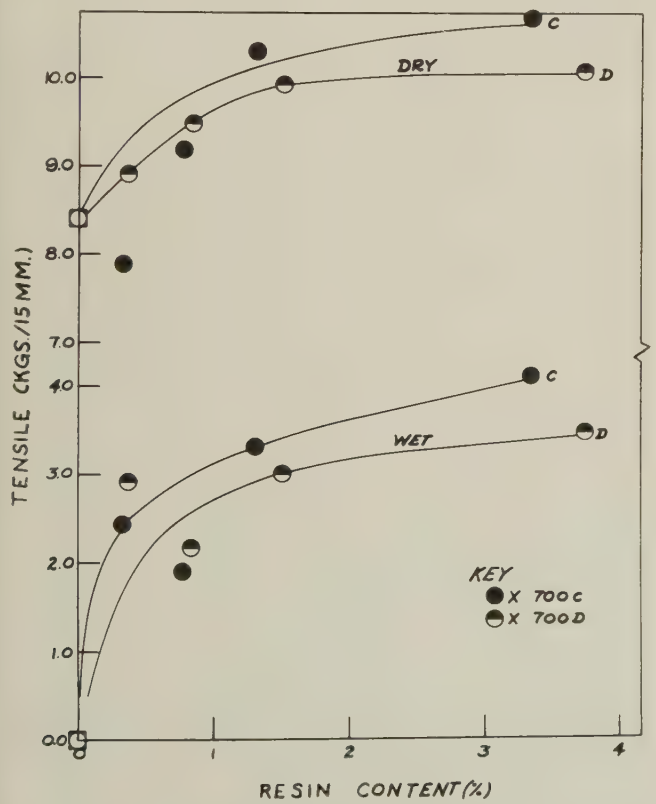

Fig. 6. Tensile variation with resin content, 20°C., oven cure: 5 min. at 150°C.

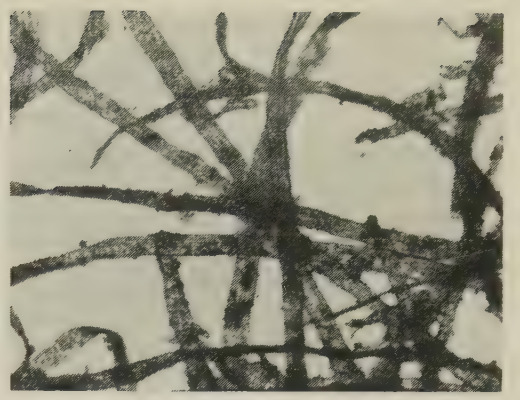

Fig. 7. Unbleached kraft containing 30% phenolic resin X 700C cured 5 min. at 150°C. ×260

increased wet and dry burst and tensile strengths (Table II), was particularly more noticeable with a 1 than a 2% addition. Thus, it may be concluded that, at any one level of addition, the distribution was good.

The effect of pulp type was one of the most distinctive of the variables examined. A 5% addition of high molecular weight resin to bleached sulphite at 20°C. decreased the dry burst and tensile strength slightly. However, a similar treatment of unbleached kraft resulted in substantial gains in dry strength (Table III). A possible explanation of these data is that many of the potential bonding sites, namely the hemicelluloses, were removed from the fiber surfaces of the sulphite during the pulping and bleaching processes. Once again the close connection between dry strength and wet strength can be noticed. In spite of the considerable difference in actual wet strength with the two pulps, the ratio of wet strength to dry strength is quite similar.

Table IV illustrates some very interesting data which from treating pulp with the three standard commercially used wet-strength resins: (1) phenol, (2) urea, and (3) melamine-formaldehyde. It was generally found that, at a given rate of addition, the greatest absolute gain in wet and dry strength was demonstrated by the pulps treated with the melamine resin, with the effects of the phenolic and urea following respectively. However, the per cent wet strengths were all reasonably comparable. With a 2% addition, the phenolic was equally as effective per unit weight of resin retained as the melamine. It has been suggested that proportional gains in strength could be obtained by increasing the retention by simply advancing the resin molecular weight. Unfortunately, though the higher retentions can be obtained, they do

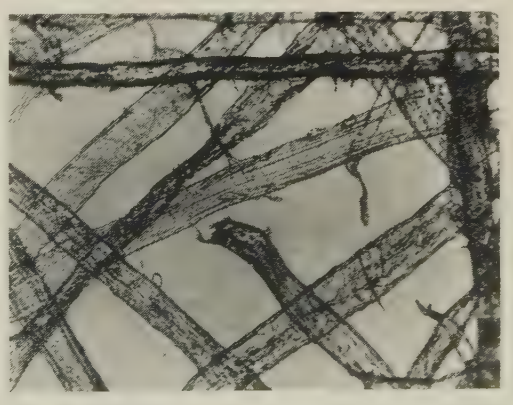

Fig. 8. Unbleached kraft—untreated. ×260

Table VI. Resin Recovery Accuracy of X 700 without Pulp and X 700A with Pulp

5% addition at 20°C., pH 4.0 with alum

Case	Sample	X 700 without pulp	X 700A with pulp
Resin added (per sheet), g.	1	...	0.0695
	2	...	0.0678
Total run		0.090	1.8125
Resin in DMF (per sheet), g.	1	0.0608	0.0226
	2	0.0633	0.0227
Resin in white water, g.	1	0.0270	1.170
Total run	2	0.0231	1.220
Resin recovered in DMF, %	1	67.5	32.6
	2	70.3	33.4
Recovered in white water, %	1	30.0	64.6
	2	25.7	67.3
Total	1	97.5	97.2
	2	96.0	100.7
Average		96.8	99.0

not always lead to greater strengths as was previously described.

RETENTION TECHNIQUE

Apparatus

The solution analyses were run on a Model DU Beckman quartz spectrophotometer. Quartz cells with quartz spacers were used. The ultraviolet source was a no. 2230 hydrogen lamp.

Procedure

A volume of white water was collected, filtered, and acidified to pH 3.0. This quantity was a representative portion of the entire run and was obtained by simulating sheetmaking conditions with a Buchner funnel equipped with a standard mesh wire screen. Thus, the huge dilution characteristic in normal handsheet preparation was not incurred. The optical density of the filtrate, at 2800 A, was determined with the Beckman. Using this value, the resin retention was calculated, using the Beers Law relationship and the procedure outlined in Table V.

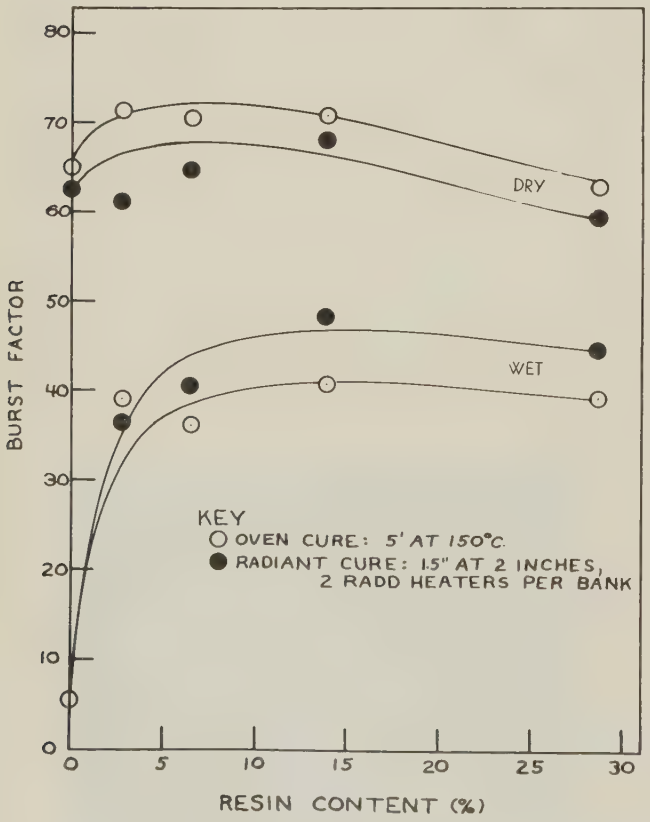

Fig. 9. Burst factor variation with resin content, X 700C, 30°C., oven and radiant cured

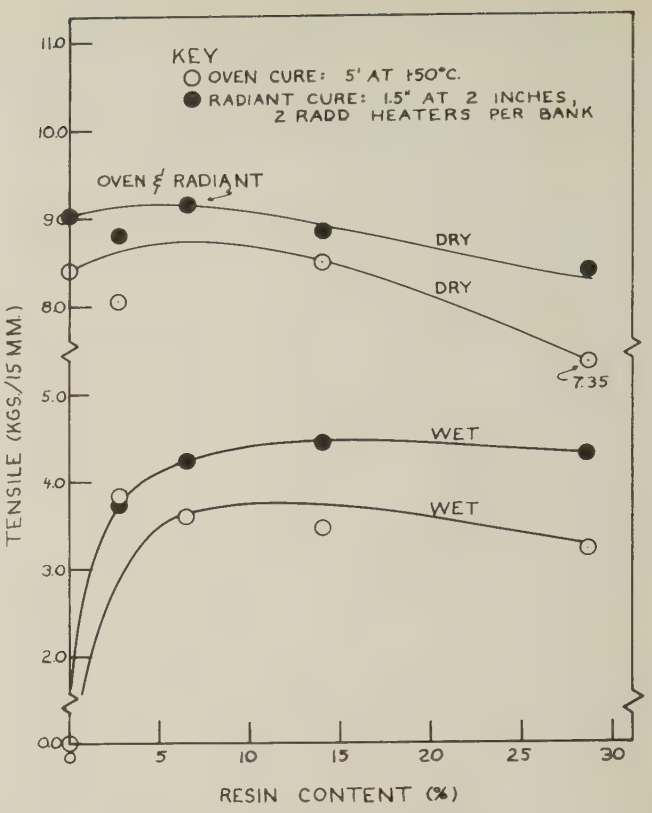

Fig. 10. Tensile variation with resin content, X 700C, 30°C., oven and radiant cured

Experimental

The resin-recovery accuracy of the technique was established for each phenolic resin by forming a pad on the Buchner from a pulp slurry treated with 5% resin and analyzing the following solutions: The resin solution was prepared by extracting the wet pad with dimethyl formamide, according to the method of Bhargava (*5*). The resin-water solution was prepared according to the above mentioned procedure. Both solutions were then acidified to pH 3.0 and analyzed for optical density at 2850 and 2800 A, respectively. The weight calculations were made in accordance with Table V, where the term "DMF" may be substituted for "White Water" by simultaneously substituting "DMF extract" for "Stock Slurry." The resin input was calculated from the oven-dry weight of the extracted pad. The recovery accuracy of both high and low molecular weight resins is demonstrated by Table VI. With the higher molecular weight Synco resins, the retention, as measured by subtracting the resin found in the white water from the resin added, is always higher than that measured directly in the dimethyl formamide extract of the pulp. This can be attributed to part of the resin being unextractable from the pulp, presumably because of crosslinking even before drying. This effect would be most apparent with high molecular weights, according to the normal theory of gelation.

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The Effect of Beating on Filtration Resistance and Its Components of Specific Surface and Specific Volume

WILLIAM L. INGMANSON and BRUCE D. ANDREWS

It was found that filtration resistance increases exponentially with beating time and that the level of filtration resistance of a whole pulp depends primarily on the amount of fines and fiber debris produced in the refining action. Fiber specific surface was increased from 7500 to 26,000 sq. cm. per g. by fibrillation in a ball mill for 250 min., whereas the surface area of the fines increased from 80,000 to 260,000 sq. cm. per g. over the same period. The external surface areas of both fiber and fines were linear functions of beating time. No change was found in wet mat apparent density (at a given pressure) with refining. However, the fiber specific volume increased rapidly and then leveled off with beating time. Relating wet mat solid fraction with bulk compressibility showed that the bulk compressibility increased in direct proportion to increases of specific volume with refining time. Since the amount of water associated with the cellulose increases with beating, the degree of fiber swelling and plasticity also increases. Thus, it was reasoned that a wet-pressed sheet will have more fiber-to-fiber contact as beating proceeds with resulting higher strength characteristics. The specific volume was found to be the same for both fibers and fines.

The work in this paper was carried out in connection with a series of integrated studies of surface properties of wood pulp. Correlations of these properties with paper strength are reported in other papers (*1*, *2*). This paper deals with the effect of beating on pulp filtration resistance and fiber properties of hydrodynamic surface area, swollen specific volume, and wet pulp mat compressibility as measured by a constant-rate filtration technique (*3*).

Recognizing the important effect of fines on pulp surface area, four sets of pulp samples were prepared from each of seven beating intervals in a ball mill. These four sets of samples differed essentially only in fines content. The samples in the first set were whole pulp with all the fines present. The second set of samples was obtained by forming the whole pulp into standard handsheets (in which fines are lost) and redispersing the wet handsheets. The third series of samples had the fines completely removed from the whole pulp by classification in a Bauer-McNett classifier, discarding all material passing through a 150-mesh screen. The fourth and final set of samples was formed from the classified pulp by forming into standard handsheets and redispersing the wet handsheets.

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EXPERIMENTAL PROCEDURES

Pulp Preparation

The pulp used in the experimental work was a bleached sulphite stock obtained in wet lap form. An undried pulp was chosen to eliminate the effect of drying on some of the physical properties to be measured. The wet lap was defibered in a laboratory pulp breaker and stored in pliofilm bags in a cold room at 40°F.

The stock was refined to varying degrees in a laboratory ball mill containing 100 porcelain balls $1^1/_4$ to $1^1/_2$ in. in diameter and revolving at 59.2 r.p.m. Three charges of 30 g. each of the stored pulp were diluted to 2 l. and dispersed for 7500 rev. in the British disintegrator. Each charge was dewatered and then all three were combined. The combined 90-g. charge was diluted with 2900 ml. of water and placed in the ball mill. The samples were beaten for 20, 50, 100, 150, 200, and 250 min., dewatered, and stored in moisture-proof containers at 40°F.

The classified samples were prepared by disintegrating a 30-g. charge of the beaten pulp in 2 l. of water for a total of 7500 rev. The dispersed sample was placed in the Bauer-McNett classifier using four screens of 8, 12, 65, and 150-mesh. The charges were classified for 15 min. and then the retained fractions were combined. The fines and fiber debris passing through the 150-mesh screen were discarded. Care was taken that both the classified and unclassified pulp samples had identical dewatering and handling treatments. The only difference between the two sets of samples was the removal of that material passing through the 150-mesh screen in the Bauer-McNett classification.

Handsheets were formed in the British sheet mold from both the classified and unclassified stocks. The wet handsheets were defibered in a pulp breaker and stored in pliofilm bags at 40°F. About 0.5% formalin (on the wet fiber basis) was added to each stored pulp to minimize bacterial action. Table I lists the pulp yield, freeness, moisture content, and handsheet drainage times for the classified and unclassified stock at different beating intervals.

Constant-Rate Filtrations

The experimental techniques and the apparatus used in carrying out a constant-rate filtration have been

Table I. Pulp Preparation Data

Refining time, min.	Pulp yield after classification, %	Schopper-Riegler freeness, cc.		Handsheet drainage time, sec.	
		Classified	Unclassified	Classified	Unclassified
0	93.7	880	870	5.0	7.2
20	89.5	870	800	5.3	6.0
50	89.4	875	765	7.6	6.3
100	83.8	840	520	5.4	12.6
150	78.5	830	375	7.2	44.2
200	76.1	800	230	8.5	85.1
250	77.6	785	205	11.1	172.7

previously discussed (*3*). Reviewing briefly, a dilute slurry of approximately 0.01% consistency is introduced at a constant level in the filtration tube and a constant rate of flow is maintained by a variable speed gear pump discharging through a rotameter. As the filtration proceeds and the mat increases in thickness, the pressure drop across the pulp mat is measured as a function of time by means of a variable speed strip chart recorder. At the end of a filtration, average specific filtration resistance is calculated from the relationship

$$R = \frac{A^2}{(dV/d\theta)^2 \mu C} \frac{\Delta P_f}{\theta} = \frac{B \Delta P_f}{\theta} \qquad (1)$$

where

R = average specific filtration resistance, cm./g.
A = cross-sectional area of bed perpendicular to direction of flow, sq. cm. (49.5 sq. cm.)
ΔP_f = over-all frictional pressure drop across the filter bed, dynes/sq. cm.
$dV/d\theta$ = volumetric rate of flow, cc./sec.
μ = filtrate viscosity, poises
C = mass of fibers in the filter bed per unit volume of filtrate, g./cc.
θ = time of filtration, sec.
B = constant in a constant-rate filtration, c.g.s. units

Calculation of Specific Surface and Specific Volume

The time-pressure drop relationships determined in the constant-rate filtrations are utilized in the calculation of specific surface and specific volume of the fibers through use of a modified Kozeny-Carman equation (*3*):

$$[c(d\theta/d\Delta P_f)]^{1/3} = [B/kS^2]^{1/3} [1 - vc] \qquad (2)$$

where

c = mass of fibers per unit volume of a uniformly compacted bed, g./cc.
$d\theta/d\Delta P_f$ = slope of a constant-rate filtration time-pressure drop curve, sec.-cm.^{2}/dyne
k = Kozeny constant, 5.55 for fibers, dimensionless
S = specific surface of fibers, sq. cm./g.
v = specific volume of fibers, cc./g.

Apparent Density as a Function of Compacting Pressure

To use equation (2), it is necessary that the wet mat density, c, be determined as a function of compacting pressure. Previous measurements of this type (*3*) have utilized the wet mat formed in the filtrations by loading the mat with a static load on a permeable piston and measuring the mat thickness. There have been two objectionable features to using mats formed in the filtrations: (1) Mat compression is influenced by a hysteresis effect, and the mat, once compressed during a filtration, does not completely recover by expanding to a zero compacting pressure thickness at the end of the filtration. (2) Because filtration resistance increases with increased amounts of refining, the thicknesses of the wet mats formed in the filtrations become progressively smaller and the precision of the thickness measurements is not adequate for highly beaten pulps.

To overcome these objectionable features, separate pulp mats were formed for apparent density determination in the following manner: one liter of pulp slurry at 0.45% consistency is added to the filtration tube. A permeable piston is placed in the tube and lowered at a slow rate such that the wet mat that builds up is never subjected to more than 5 cm. of water pressure drop. After the wet mat of basis weight about 0.1 g. per sq. cm. is formed, static loads are added to the piston, and mat density is measured as a function of compacting pressure.

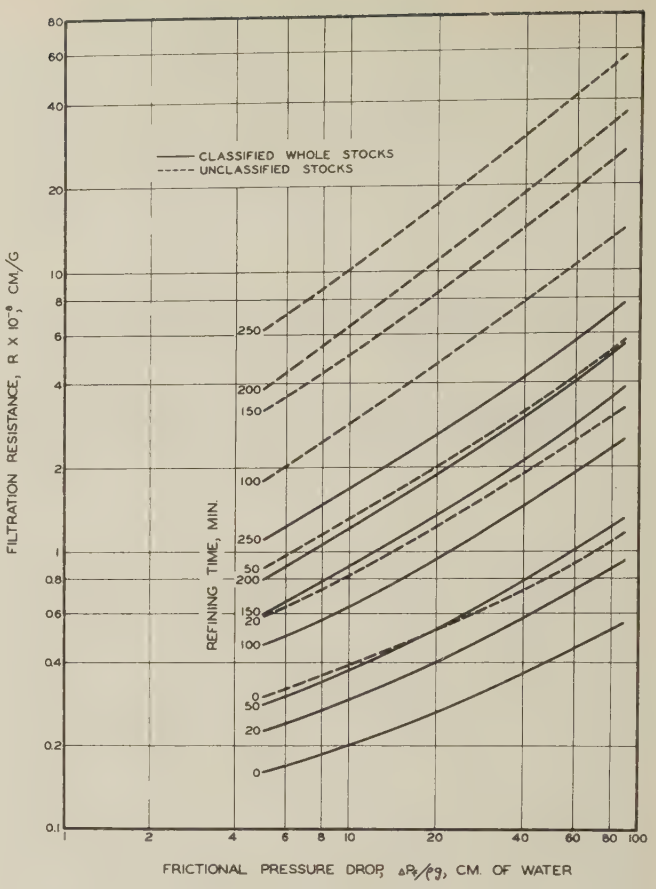
CLASSIFIED WHOLE STOCKS
UNCLASSIFIED STOCKS
REFINING TIME, MIN.
FILTRATION RESISTANCE, R X 10⁻⁶, CM./G
FRICTIONAL PRESSURE DROP, ΔPf/fg, CM. OF WATER

Fig. 1. Filtration resistance as a function of pressure drop

RESULTS AND DISCUSSION

Filtration Resistance

Average specific filtration resistance was calculated from equation (1) for duplicate runs of classified and unclassified pulps for both the whole stock and stock which had been formed into handsheets. The duplicate runs agreed with an average precision of 1 to 2%, the higher deviations being shown by the highly beaten pulps.

The filtration resistances for the unclassified whole pulps were from 10 to 60% higher than for the same stock formed into handsheets, the greater deviations occurring in intermediate beating ranges. This difference represents a loss of fines during handsheet formation. However, the filtration resistances of the classified whole pulp and handsheet pulp were not significantly different, indicating the completeness of fines removal in the Bauer-McNett classification.

Figure 1 shows filtration resistances of the whole stocks for classified and unclassified pulps. The

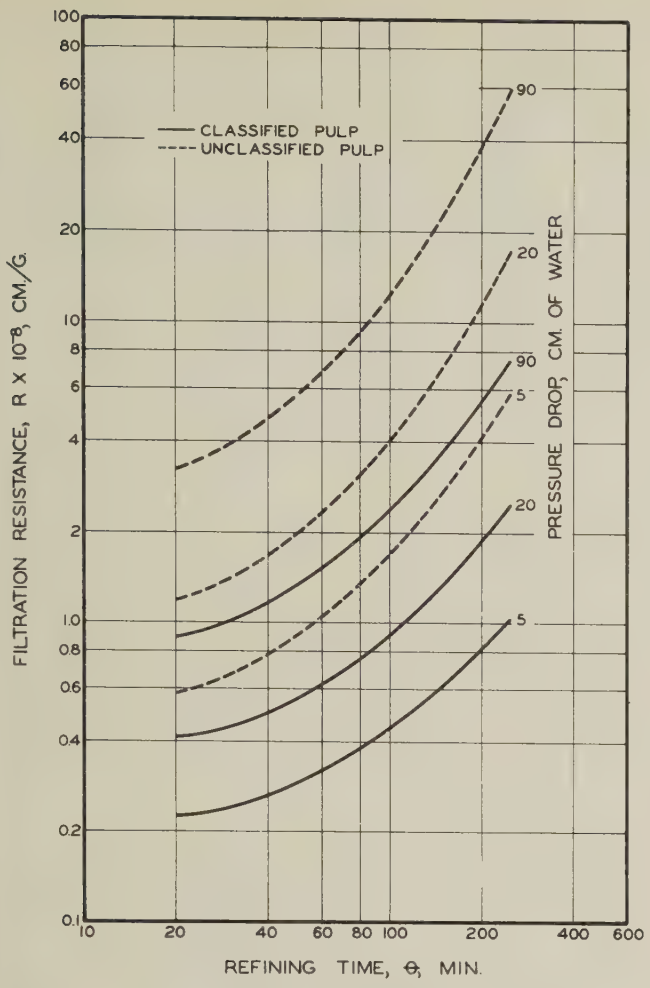

Fig. 2. Filtration resistance as a function of refining time at given pressure drops

marked effect of fines on filtration resistance is apparent from these data. In the unbeaten pulp where relatively few fines are present, the unclassified pulp has about a 90% higher filtration resistance. In the highly refined pulp with considerable fines present, the filtration resistance was approximately 600% higher for the unclassified sample.

The data shown in Fig. 1 were cross-plotted to show the effect of refining time on filtration resistance with pressure drop as a parameter in Fig. 2. The nature of the empirical relationship between filtration resistance and refining time is the same for classified and unclassified pulps at any pressure drop, and is given by

$$R = a\theta^n + b \qquad (3)$$

where

θ = refining time in the ball mill
a, b, n = empirical constants for a given pulp at a fixed pressure drop

The exponent, n, is greater for unclassified pulps as would be expected, and indicates a greater rate of increase of filtration resistance with refining time because of the development and presence of fines. The exponent, n, also increases for a given pulp with increasing pressure drop, ranging from about 1 to 1.5 for classified pulp over a pressure drop range of 5 to 90 cm. of water, and from 1.5 to about 2 for unclassified pulps over the same pressure drop range. The empirical constant, b, represents filtration resistance at zero refining time. It is, of course, larger for the unclassified pulp as compared to classified stock, and also increases with increasing pressure drop because of the compressible nature of the wet pulp mats. The empirical constant, a, determines the level of filtration resistance at a given refining time, and is affected by the presence of fines and by pulp compressibility in a manner similar to that for constant b.

It will be shown later that differences observed in the behavior of filtration resistance for unclassified and classified pulps can be attributed *entirely* to the higher specific surfaces of the fines and fiber debris which are present in the unclassified pulp samples. The two other components of filtration resistance, fiber specific volume and wet mat apparent density, are unaffected by fines and fiber debris.

A correlation between freeness and filtration resistance (at 10 cm. of water, the initial head in the Schopper tester) is shown in Fig. 3 and is similar to previously reported data (*3*). The lack of sensitivity in the high freeness range of 800 to 900 ml. S.-R. is apparent, and the scatter from any given functional relationship makes it clear that freeness is an inadequate measure of drainage resistance. The same criticisms apply to handsheet drainage time in the British sheet mold taken as a measure of filtration resistance. These data are correlated in Fig. 4.

Wet Pulp Mat Apparent Density

Apparent density measurements were made in duplicate at four pressures, from 17 to 100 cm. of water, on all the pulps, classified and unclassified, whole stock and handsheet stock. No significant differences were found between the apparent densities of any of the pulps, and the average values for all the sulphite pulps are shown in Fig. 5 as a function of compacting pressure. The empirical correlation is of the form $c = Mp^N$, where p is compacting pressure and M and N are constants, and is similar to those reported previously for other pulps (*3*).

The fact that beating over wide ranges and the presence or absence of appreciable amounts of fines did not change the nature of the wet pulp apparent density-compacting pressure relationship would imply that an experimental measure of these variables on an unbeaten pulp could be safely used for the same pulp at any degree of refining. This fact would greatly reduce the amount of data required to calculate fiber specific surface and specific volume as a function of refining time. Because of the relatively low filtration resistance

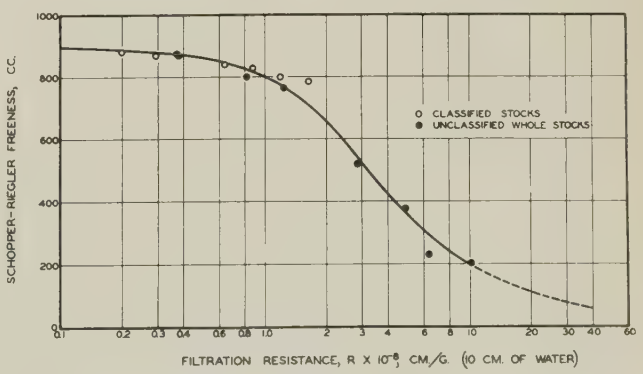
SCHOPPER-RIEGLER FREENESS, CC.
O CLASSIFIED STOCKS
● UNCLASSIFIED WHOLE STOCKS
FILTRATION RESISTANCE, R X 10⁻⁸, CM./G. (10 CM. OF WATER)

Fig. 3. Freeness as a function of filtration resistance

Table II. Fiber Specific Surfaces

Pulp	Refining interval, min.: 0	20	50	100	150	200	250
	Specific surface, S, sq. cm./g.						
Classified whole stock	7,500	8,900	10,400	14,000	18,100	21,000	24,700
	7,900	9,400	10,500	14,200	18,300	21,600	25,700
Classified handsheet stock	7,600	9,300	10,700	14,800	17,800	20,800	26,800
	7,500	9,500	10,700	14,800	17,600	21,400	26,700
Av.	7,600	9,300	10,600	14,400	18,000	21,400	26,000
Unclassified whole stock	10,400	17,100	22,900	37,400	52,000	62,800	78,400
	10,700	17,800	22,500	37,400	52,000	63,800	80,400
Av.	10,600	17,400	22,700	37,400	52,000	63,300	79,400
Unclassified handsheet stock	10,100	13,500	17,200	28,800	39,600	54,200	76,400
	10,100	13,200	17,800	28,900	38,600	54,300	76,300
Av.	10,100	13,400	17,500	28,800	39,100	54,200	76,400

of unbeaten pulps, these wet mats are more easily and quickly formed than for beaten stock.

The ball-mill refining of the pulps used in this study did not produce any relatively large reductions of fiber length. However, a previous study (*4*) compared apparent density-compacting pressure data for an unbeaten and beaten (620 ml. S.-R.) spruce sulphite pulp in a laboratory Valley beater, and no significant difference was found. Thus, it would appear that fiber cutting in refining would not alter the density-compacting pressure relationship.

Apparent density-compacting pressure data are not a true indication of bulk compressibility. The solid fraction of the wet mat, that is, the ratio of volume of solids to total mat volume, resists the compacting pressure, and thus the rate of change of solid fraction with applied pressure would be a better measure of bulk compressibility characteristics of the fibers. Since the solid fraction is equal to the product of specific volume and apparent density, vc, and apparent density, c, is unaffected by refining, then the change in bulk compressibility is directly proportional to changes in specific volume, v, with refining action.

Specific Surface

Fiber specific surfaces were calculated from the duplicate filtration runs and averaged wet mat apparent density data using equation (2) and are reported for all the pulps in Table II. There was no significant difference in the surface areas of the whole pulp and handsheet pulp from the classified stock, but as expected there were large differences between whole pulp and handsheet pulp in the unclassified samples and between unclassified and classified pulps. These data are shown graphically in Fig. 6.

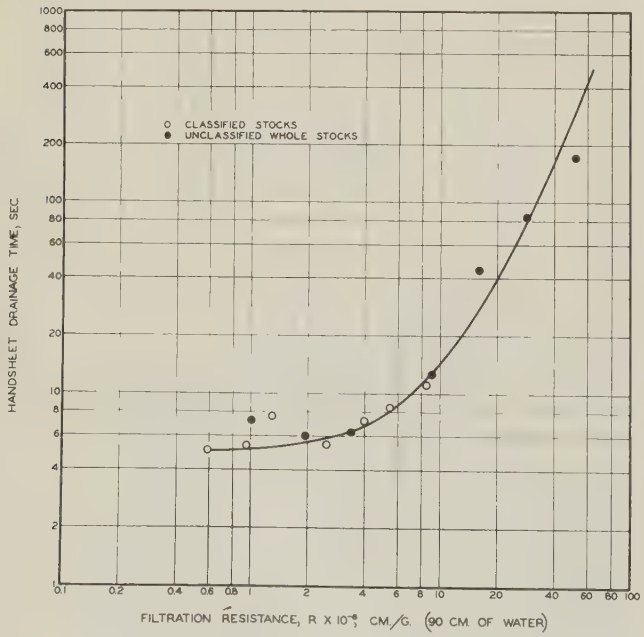
CLASSIFIED STOCKS
UNCLASSIFIED WHOLE STOCKS
HANDSHEET DRAINAGE TIME, SEC
FILTRATION RESISTANCE, R X 10⁻⁹, CM./G. (90 CM. OF WATER)

Fig. 4. British sheet mold drainage time as a function of filtration resistance

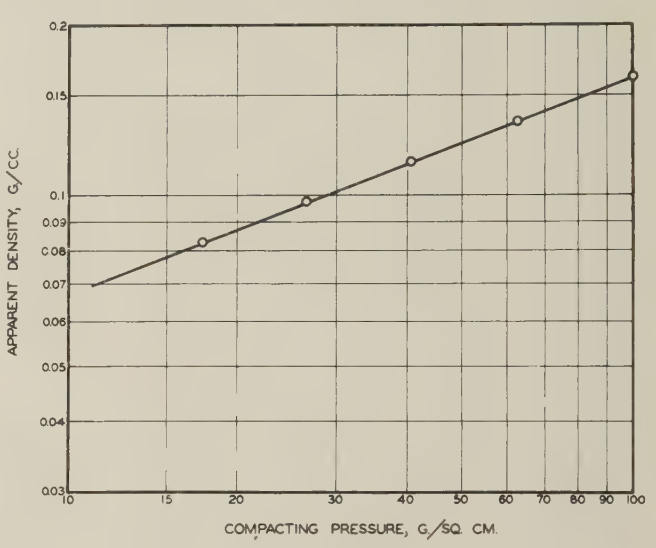

Fig. 5. Wet pulp mat apparent density as a function of compacting pressure

Figure 6 shows that the rate of development of specific surface with refining is very nearly constant for both unclassified and classified pulps. Area developed by fibrillation (classified pulp) is about 4000 sq. cm. per g. for each hour of refining, whereas area development by fibrillation and production of fines (unclassified pulp) is about four times as great, or 16,000 sq. cm. per g. per hr.

The surface area of the handsheet pulp from the unclassified stock shows the effect of a varying degree of fines loss. The unbeaten whole sample, with relatively few fines has a surface area only slightly greater than the handsheet stock, indicating relatively little effect because of fines loss in handsheet formation. The same phenomenon is observed for the highly beaten pulps at 250 min. beating time. However, the loss of fines, as evidenced by a changing surface area, goes through a maximum at an intermediate beating level. These facts are interpreted as indicating that the retention of fines in the handsheet formation step becomes greater as refining proceeds, because the equivalent pore size in the wet mat is becoming progressively smaller as the fibers are fibrillated. The surface

area reduction goes through a maximum because two variables are changing simultaneously, but at different rates, i.e., interfiber pore size is decreasing and the amount of fines is increasing.

The yield data on classification in the Bauer-McNett from Table I can be used in conjunction with the surface areas from Table II to calculate the specific surface of the fines and fiber debris: By a material balance,

$$S_1x_1 + S_2x_2 = S_T \qquad (4)$$

where

S_1 = specific surface of fibers (classified pulp)
S_2 = specific surface of fines
S_T = specific surface of fibers and fines (unclassified pulp)
x_1 = weight fraction of fibers
x_2 = weight fraction of fines

The results of the calculations using equation (4) are shown in Fig. 7 which relates the specific surface of the fines to refining time. Because of the sensitivity of the calculated values of the specific surface of the fines to the weight ratios of fines, the data show considerable scatter from any given functional relationship with refining time. However, within the precision of the yield data from Table I, the surface area of the fines increases linearly with beating time at a rate of about 40,000 sq. cm. per g. for each hour of refining.

The high level of the surface area of fines from 80,000 to 260,000 sq. cm. per g. makes it clear that small amounts of this type of material can have an enormous effect on the specific surface of a pulp mixture, and hence a great influence on the resulting filtration resistance of the stock. The high area results from the fine state of subdivision of the fibrous material to the extent that fines have no true fiber identity but are small fiber and fibril fragments of irregular granular shape. Of course, the Bauer-McNett classification in which

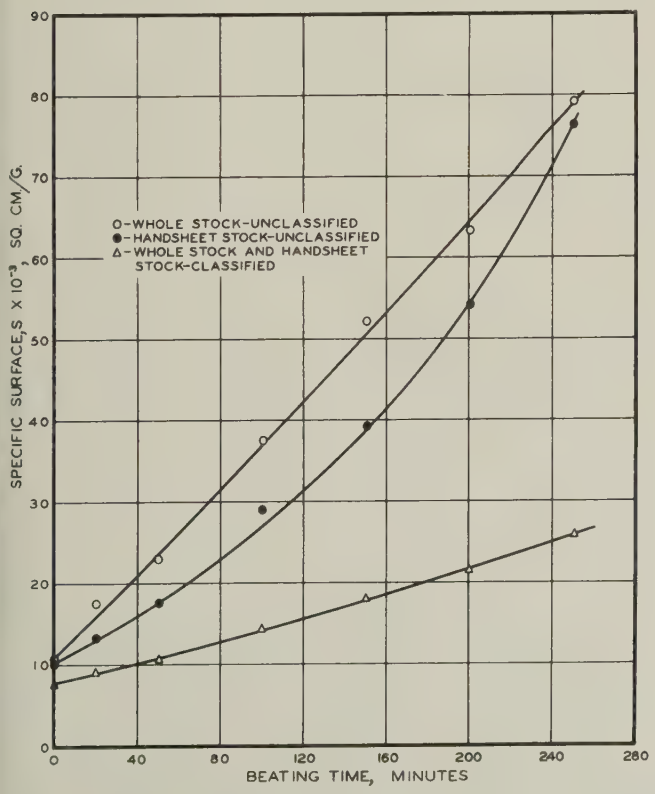

Fig. 6. Effect of refining on the development of specific surface

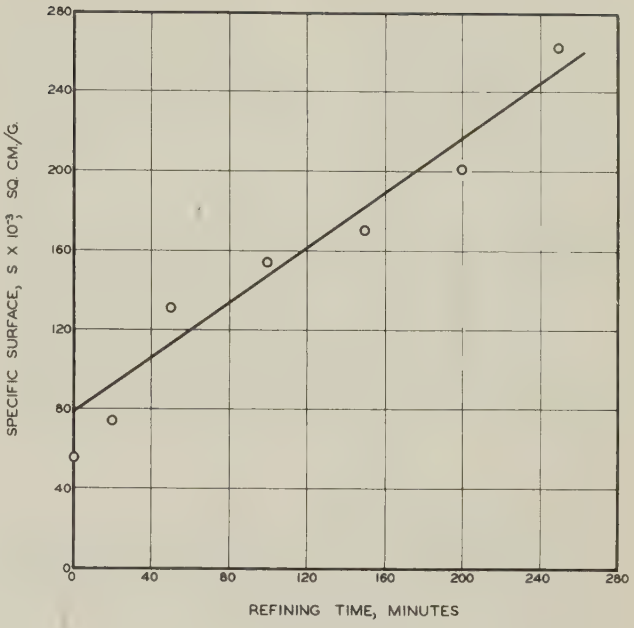

Fig. 7. Effect of refining on specific surface of fines

fines and fiber debris were defined as material passing a 150-mesh screen is arbitrary, and undoubtedly some discrete fibers of small diameter were also removed. This fact would contribute to calculating a too low value of specific surface of fines, and probably the surface area of the true fines and fiber debris is somewhat higher than those shown in Fig. 7.

The implications of the relative values of specific surface of fibers and fines with respect to pulp evaluation and sheet strength correlation with surface area are discussed in detail in a succeeding paper (*1*). However, it is obvious from the data of Fig. 6 that it would be unrealistic to try to correlate strength properties of handsheets of varying amounts of fines with specific surface of a whole pulp mixture in which the presence of relatively small amounts of fines substantially determines the level and development of external surface area. Because of tremendous geometric differences, external surface area of fines and fiber debris will have a less significant effect on ultimate sheet strength than the much smaller, but perhaps more important, area developed by fiber fibrillation and fiber swelling.

Specific Volume

Values of wet fiber specific volumes were calculated simultaneously with specific surfaces for all the pulps using equation (2). The results of duplicate determinations are given in Table III. The data show that there is no significant difference in the specific volumes of

Table III. Fiber Specific Volumes

Pulp	*Refining interval, min.* 0	20	50	100	150	200	250
Classified whole	1.85	2.36	2.62	2.90	2.91	3.02	3.17
stock	1.81	2.14	2.54	2.88	2.98	2.97	3.05
Classified hand-	1.96	2.19	2.44	2.66	3.02	2.97	3.06
sheet stock	1.99	2.16	2.46	2.70	3.04	3.14	3.11
Unclassified	2.09	2.55	2.72	2.83	3.09	3.14	3.10
whole stock	2.04	2.49	2.71	2.83	3.04	3.10	3.00
Unclassified	1.93	2.38	2.69	2.79	2.96	3.11	3.00
handsheet	1.91	2.39	2.65	2.82	2.91	2.99	3.01
stock							
Av.	1.95	2.34	2.60	2.82	2.99	3.05	3.06

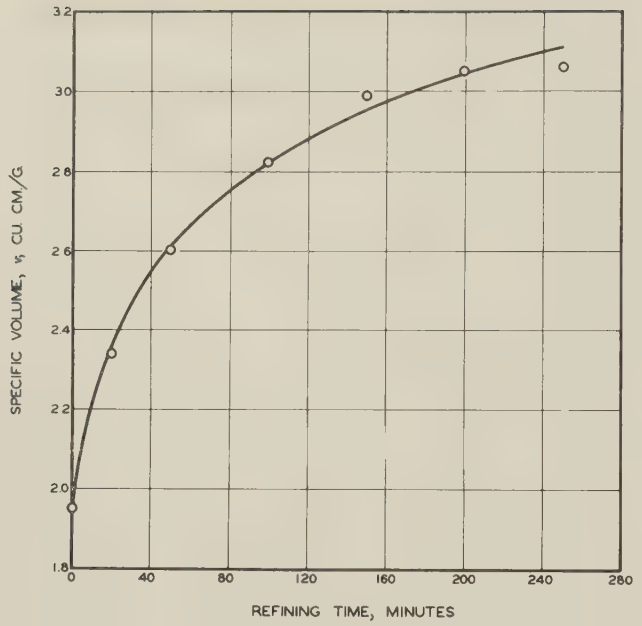

Fig. 8. Effect of refining on the development of specific volume

fibers or fines, and for a given pulp, specific volume increases with refining time irrespective of fines production. These data support the findings of Mason and Carroll (*5*) who reported no difference between hydrodynamic specific volumes of different screen fractions from a Bauer-McNett classification and found an increase of specific volume with refining in a laboratory Valley beater.

The averaged specific volume data from Table III are shown in Fig. 8 as a function of refining time. The data show a rapid initial increase of specific volume with a gradual levelling off at higher degrees of beating. Since the specific volume calculated from the Kozeny equation is defined in a hydrodynamic sense, it represents the volume denied to fluid flow per unit mass of dry cellulose. The volume which is denied to flow consists of cellulose and water associated with the cellulose. Thus, as beating proceeds, the amount of water associated with the cellulose increases, and, hence, the amount of fiber swelling must also increase. The water associated with the cellulose is shown in Table IV and is obtained by subtracting the pycnometric specific volume of cellulose in water, 0.62 cc. per g. (*6*), from the swollen specific volumes taken from the curve in Fig. 8.

It has been shown previously (*3*) that the hydrodynamic specific volume has a true physical significance in that it may be used to calculate the moisture contents of fiber mats under fluid stress. The water in a wet mat consists of water associated with the cellulose in intrafiber pores and water in the interfiber pores of

Table IV. Water Associated with Swollen Fibers

Beating interval, min.	*Specific volume, v, cc./g.*	*Water associated with fibers, g./g.*
0	1.95	1.33
20	2.36	1.74
50	2.62	2.00
100	2.82	2.20
150	2.96	2.34
200	3.04	2.42
250	3.11	2.49

the porous mat structure. If the water in the interfiber pores could be completely removed by some means such as displacement with another fluid, e.g., air, then the hydrodynamic specific volume is a measure of the final moisture content of the wet mat. The removal or this remaining water requires distortion of the swollen fiber structure, and Van den Akker *et al.* (*7*) have shown it may be completely removed by the application of high compressive stress.

As noted in the discussion of wet mat apparent densities, the mat solid fraction, defined as volume of solids per unit volume of wet bed, is given by the product of hydrodynamic specific volume, v, and apparent density, c. Water is included in this so-called solid fraction because it is not free to move, at least in the range of compacting pressures used in the filtrations (0 to 100 g. per sq. cm.). The greater the solid fraction at a given compacting pressure, the more intimately the swollen fiber surfaces will be in contact, and thus, higher degrees of bonding should result. Therefore, there should be a correlation between strength properties of handsheets and the solid fraction, vc, of the wet-pressed handsheets. Since handsheets are prepared at the same degree of wet pressing, and apparent density, c, was found not to be a function of refining time at a given pressure, the development of specific volume, v, with refining time should be directly proportional to the handsheet solid fraction at various refining times. Thus, a good correlation between specific volume and some strength property related to degree of bonding would be anticipated.

CONCLUSIONS

The level of filtration resistance of a whole pulp is largely determined by the amount of fines produced in beating because of the high surface area of the fines and fiber debris in comparison to the fibers. Where filtration resistance is to be used to predict rate of water removal, it is essential that the pulp that has been analyzed contain exactly the same amount of fines as in the situation to be analyzed. For example, on a pulp washer, it would be necessary to take a sample for laboratory evaluation of filtration resistance from the wire of the washer at the end of the washing cycle.

Filtration resistance was found to be a power function of refining time in a ball mill, the exponent of refining time varying from about 1.5 to 2.0 depending upon the specified pressure drop across the fiber mat over a range of 5 to 90 cm. of water. Neither freeness nor drainage time provides an adequate measure of filtration resistance, regardless of the amount of fines present in the pulp. These empirical tests are particularly insensitive in the high freeness range of 700 to 900 ml. S.-R.

The components of filtration resistance were analyzed as a function of beating time, and both fiber external surface area and fiber specific volume were found to increase with degree of beating, whereas wet mat apparent density at a given compacting pressure was independent of beating time. Taking the wet fiber mat solid fraction as a measure of bulk compressibility shows that the solid fraction, at a given compacting pressure, increases in direct proportion with increases in specific volume. As beating proceeds, the amount of water associated with the cellulose increases and the

degree of fiber swelling and plasticity increases. Thus fiber surfaces have greater contact in the wet-pressed sheet and the amount of ultimate bonding should be greater. The specific volume of fibers or fines is the same at a specified beating interval. Water-swollen specific volume also provides a measure of the limit of water removal without fiber deformation.

Although fiber specific volume increases rapidly during early stages of beating and then levels off at high degrees of beating, pulp specific surfaces increase very nearly linearly with refining time. The external surface area of fines and fiber debris were estimated and found to be more than ten times as great as those of the fibers. The external *fiber* surface area was found to be more than tripled by fibrillation of fibers in a ball mill action. Because of tremendous geometric differences between discrete fibers and fines, with no fiber identity, their contributions to ultimate sheet strength will be considerably different and must be taken into consideration in future correlations of specific surface and strength characteristics.

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A Thermodynamic Interpretation of the Swelling of Cellulose in Organic Liquids: The Relations Among Solubility Parameter, Swelling, and Internal Surface

EDWARD F. THODE and ROBERT G. GUIDE

By application of the Hildebrand solubility parameter concept, a unified hypothesis is presented to explain the swelling behavior of cellulose in organic liquids and also the apparent total surface (mostly internal) obtained on drying from such solvents. Data for nonpolar solvents show an inverse relation between "total surface area" and solubility parameter in the range 7.0 to 10.0. It is shown that the apparent surface area by nitrogen adsorption of wood cellulose is a function of the cohesive energy density of the solvent from which it is dried. It is concluded that this surface area is a function of the swelling produced by that solvent for two reasons: first, the more the polymer elements are swollen, the more conformable they are, leading to greater collapse of internal pore structure upon drying. Second, the greater the cohesive energy density of the solvent, the greater the ability of the retreating solvent layer to pull elements of the polymer structure together.

Understanding of the swelling of both the linear and the cross-linked polymers in solvent systems has greatly increased in the past few years, thanks particularly to the thermodynamic efforts of Hildebrand, Scatchard, Huggins, Flory, Gee, and Scott (*1*, *2*). While the solubility and swelling in various aqueous solvents have been extensively treated, the limited swelling of cellulose in organic solvents has been largely neglected. Spurlin (*3*) has suggested that the swelling of cellulose in organic liquids is related to the solubility parameter, or cohesive energy density, of the solvent, but showed no correlations to establish the claim. Kress and Bialkowsky (*4*) were responsible for the first significant work in the field but did not treat their data from a thermodynamic viewpoint because of the lack of good analytic expressions at the time.

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Recent work in these laboratories by Haselton (*5*), and Merchant (*6*) concerning nitrogen adsorption on wood cellulose dried by solvent displacement has renewed interest in the mechanism by which cellulose fibers are affected by organic liquids. It was the idea of the present authors that seemingly unrelated phenomena observed for various cellulose-solvent systems, wherein a certain amount of swelling took place, could be drawn together into a unified concept. Essential to this concept is the notion that the cellulose fiber may be considered as a fairly highly cross-linked polymer of porous structure. This porous structure exists from the time of formation of the fiber and for as long as the fiber remains in water or another swelling medium, but because of the flexibility of the polymer units, this structure tends to collapse upon drying. An extensive treatment of this subject from the point of view of free surface energy has recently been published by Stamm (*7*). Most of the arguments presented by that author relate primarily to water and aqueous solvents.

It is the object of this paper to demonstrate that the concepts developed for the limited swelling of cross-linked polymers also explain the swelling of cellulose in organic liquids. It is also the object of this discussion to demonstrate that the solubility parameter concept is useful in analyzing the changes in the porous structure of the wood cellulose fiber which take place on drying, and that there is a definite relationship between these changes and the degree of swelling which preceded them.

FREE ENERGY AND HEAT OF MIXING: SOLUBILITY PARAMETER

It is a necessary consequence of the laws of thermodynamics that solubility behavior should depend on the

Nomenclature

A = surface area of W-A-N dried fibers, square meters per gram (*6*)
a = constant
b = constant
ΔE^V = energy of vaporization
ΔF_o = partial molal free energy change of solvent
ΔF^m = free energy of mixing
$\overline{\Delta F}^{EL}$ = free energy of elastic stretching
f = function
h = constant
k = constant
M = effective total molecular weight of polymer
M_c = effective molecular weight of polymer between cross-links
m = volume ratio, V_p/V_o
m_c = volume ratio, V_c/V_o
Q = degree of swelling, ϕ_o/ϕ_p
R = gas constant, 1.99 cal. per (mol) (°K.)
$\overline{\Delta S}^{EL}$ = entropy of elastic stretching
T = temperature, °K.
V = molal volume, cubic centimeters per mol
V_o = molal volume, solvent
V_p = molal volume, polymer
V_c = molal volume, polymer between cross-links
δ = solubility parameter
δ_o = solubility parameter of solvent
δ_p = solubility parameter of polymer
μ = mixing parameter
μ_s = entropy contribution to mixing parameter
ϕ_o = volume fraction of solvent in swollen system
ϕ_p = volume fraction of polymer in swollen system

free energy relationships involved. For pure liquids and for soluble polymers, the free energy of mixing is the only concern, but for systems involving cross-linked polymers which swell but do not dissolve, both mixing and the elastic stretching of the polymer chains are involved. Further, for polymers in which only swelling takes place, the swelling equilibrium should be determined by the conditions where the sum of the partial molal free energy terms for mixing and elastic stretching are equal to zero.

Analytically speaking,

$$\overline{\Delta F}_o = \overline{\Delta F}^m + \overline{\Delta F}^{EL} \qquad (1)$$

where ΔF_o is the partial molal free energy change of the system components, ΔF^m is the free energy of mixing, and ΔF^{EL} is the free energy of elastic stretching. As an approximation for straight chain polymers, Huggins (*2a*) and Scott (*2d*) have suggested the expression,

$$\overline{\Delta F}^m = RT\left[\ln \phi_o + \left(1 - \frac{1}{m}\right)\phi_p + \mu\phi_p^2\right] \qquad (2)$$

where ϕ_o and ϕ_p represent the volume fraction of liquid and of polymer, respectively, in the dissolved or swollen system, m the ratio of molal volumes, V_p/V_o, and μ is a mixing parameter. For cross-linked systems, $m \rightarrow \infty$, so equation (2) becomes

$$\overline{\Delta F}^m = RT\,(\ln \phi_o + \phi_p + \mu\phi_p^2) \qquad (3)$$

Although it does not entirely meet the requirements of theory, the expression,

$$\mu = \mu_s + \frac{V_o\,(\delta_p - \delta_o)^2}{RT} \qquad (4)$$

is commonly employed to express the mixing parameter, where μ_s represents the entropy contributions and δ_p and δ_o, in the heat of mixing term, are the solubility parameters of polymer and solvent, respectively.

The free energy of elastic stretching for a perfect rubber has been evaluated by Flory and Rehner (*8*) by ignoring the heat contribution. The heat of stretching is unknown but is certain to be small and thus may be justifiably taken as zero. Thus, we have

$$\overline{\Delta F}^{EL} = -T\overline{\Delta S}^{EL} \qquad (5)$$

Then, by assuming a regular tetrahedral model of the polymer elements between cross-links and a normal (Gaussian) distribution, these workers express the entropy of elastic stretching as

$$\overline{\Delta S}^{EL} = -R\left(\frac{V_o}{V_c}\right)\left(1 - 2\frac{M_c}{M}\right)\left(\phi_p^{1/3} - \frac{\phi_p}{2}\right) \qquad (6)$$

If a polymer is sufficiently cross-linked, M, the total effective molecular weight in the above equation, is much greater than M_c, the molecular weight between cross-links. If the symbol, m_c, is used to express the ratio, V_c/V_o, for a well cross-linked polymer, equation (6) reduces to

$$\overline{\Delta S}^{EL} = -\frac{R}{m_c}\left(\phi_p^{1/3} - \frac{\phi_p}{2}\right) \qquad (7)$$

The combination of equation (1), (3), (4), (5), and (7) yields the complete relationship for a substance such as an "ideal" rubber.

$$\overline{\Delta F}_o = RT\left[\ln \phi_o + \phi_p + \left(\mu_s + \frac{V_o(\delta_p - \delta_o)^2}{RT}\right)\phi_p^2 + \frac{1}{m_c}\left(\phi_p^{1/3} - \frac{\phi_p}{2}\right)\right] \qquad (8)$$

At equilibrium swelling, $\overline{\Delta F}_o = 0$, and, since $\phi_o = 1 - \phi_p$, equation (8) takes the form,*

$$\frac{\ln(1 - \phi_p) + \phi_p + (1/m_c)\left[\phi_p^{1/3} - (\phi_p/2)\right]}{\phi_p^2} = -\left[\mu_s + \frac{V_o(\delta_p - \delta_o)^2}{RT}\right] \qquad (9)$$

Equation (9) is not useful to us in an interpretation of phenomena involving highly swollen cellulose, because the term, $1/m_c\,[\phi_p^{1/3} - (\phi_p/2)]$, representing the entropy of elastic stretching, was derived for an ideal material which could hardly be compared with cellulose. However, for swelling in very poor solvents there is really so little elastic stretching that the term for the free energy change involved becomes negligible, *whatever its form*. In the particular form given above, it may be seen that at a value of $\phi_p = 0.98$, for example, the elastic stretching term accounts for less than one per cent of the left-hand side of equation (9), (m_c assumed as 50). In effect, therefore, we have only to deal with equation (3) and are not limited by the nature of the polymer, only by the assumption that the polymer-solvent system is analogous to one phase of a binary liquid system of partially miscible components. This simplified expression for *very limited* swelling is

$$\frac{\ln(1 - \phi_p) + \phi_p}{\phi_p^2} = -\left[\mu_s + \frac{V_o(\delta_p - \delta_o)^2}{RT}\right] \qquad (10)$$

From the work of Richter, Herdle, and Wahtera (*11*) and of Kress and Bialkowsky (*4*), among others, it is safe to assume that nonpolar organic liquids swell cellulose to but a very minor extent, usually on the

* For further elucidation of this equation and the relationships involved, the reader is referred to the original paper by Scott and Magat (*9*) and to the review article by Treloar (*10*).

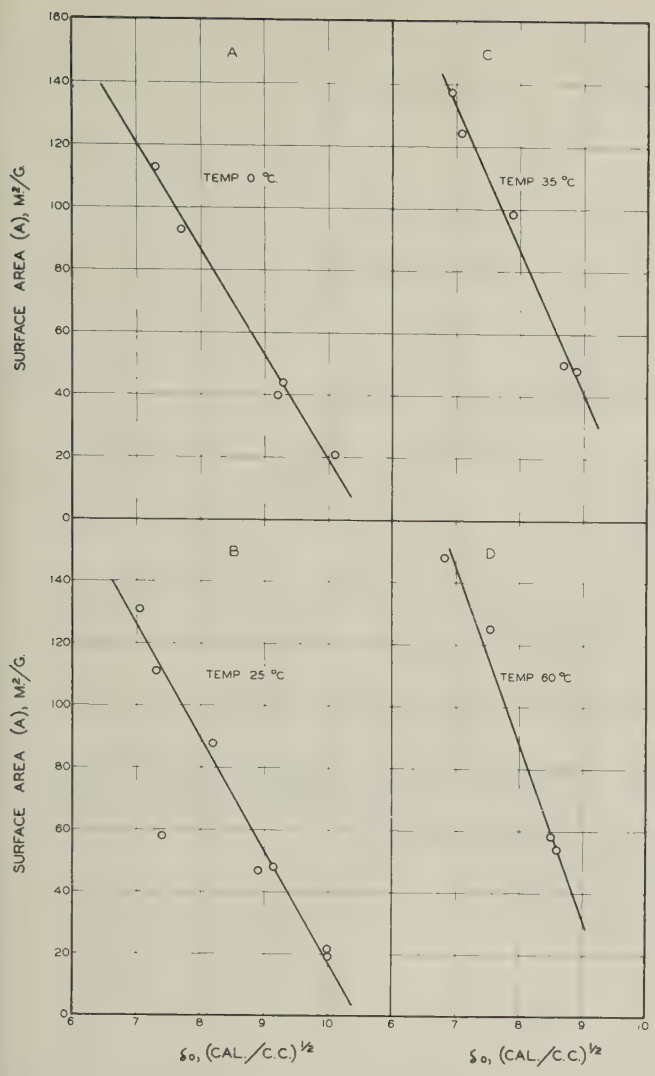

Fig. 1. Surface area (by nitrogen adsorption) of wood pulp fibers as a function of the solubility parameter of the solvent removed by drying. **[*Surface area computed from Merchant (6)*]**

order of but a few per cent. Thus, equation (10) can be applied with confidence to such systems.

NONPOLAR SOLVENT EFFECTS ON CELLULOSE STRUCTURE

In his extensive study of the total surface and pore-size distribution of wood cellulose by nitrogen adsorption, Merchant (*6*) examined effects of varying the final solvent from which the sample was dried and the temperature of drying. He employed a technique of displacing the water from swollen samples with methanol and the methanol with anhydrous nonpolar solvent. By this technique, the cellulose was preserved in a state similar to an aerogel with a specific surface area ranging from 30 to 140 sq. m. per g. In discussing his results, Merchant gives this interpretation of the process:

"Before a liquid hydrocarbon evaporates from a fiber pore, a meniscus appears at the pore entrance and thus the internal tension of the liquid tends to collapse the pores. These pores, or capillaries, have neighboring structural limits such as fibrils or microfibrils as boundaries.... The extent to which pores collapse or new contacts between structural units are made will be a function of surface tension, other factors remaining constant.... As surface tension increases, the total pore volume decreases, whereas the amount of enmeshed or retained liquid increases." [See also comment by Stamm (*7*).]

Merchant goes on to point out that if liquid molecules are trapped between structural units, they will hold these units apart, and larger (bulkier) molecules will hold the structure further apart than smaller ones. As experimental evidence, he cites a slightly larger surface area obtained at equal surface tension for cyclohexane in contrast with *n*-hexane.

If one hypothesizes that even the small amount of swelling of the cellulosic material which is accomplished by imbibition of nonpolar solvents has a significant plasticizing effect, then it is logical to expect that the deformation of the microstructural elements postulated by Merchant will be affected by the degree of plasticization. Under the influence of one or both of the related thermodynamic properties, surface tension and cohesive energy density, of the retreating liquid solvent in the pore, the neighboring structural elements should be pulled together better, the better they are plasticized. Thus, the surface area available for nitrogen adsorption should be an inverse function of the degree of plasticization or, what amounts to the same thing, the degree of swelling. If we define the swelling parameter, $Q = (1 - \phi_p)/\phi_p$, then the last statement given above may be expressed as the general mathematical function,

$$A = f(Q) \qquad (11)$$

where A is the surface area by nitrogen adsorption and $f(Q)$ is some function of Q such that A will decrease as Q increases.

As is shown in Figs. 1 a–d,* at constant temperature, the area by nitrogen adsorption is inversely proportional to the solubility parameter of the solvent. Since cellulose itself is considered to have a high solubility parameter, intuitively, high solubility parameter of the solvent should be connected with high swelling and more plasticization, thus less surface area.

Analytically, the relationship may be demonstrated as follows: It is necessary to simplify equation (10) in some rational manner consistent with the limitations implied by the system cellulose–nonpolar solvent. If one assumes a constant value of $\mu_s = 0.3$ and of $V_o = 100$ (the first of these assumptions is apparently justified from experiments on the other systems, while the other is a good average figure for our systems), then the term $(\delta_p - \delta_o)$ can be evaluated for various values of ϕ_p from equation (10). Q can be evaluated according to its definition also in terms of various values of ϕ_p. Cross-plotting of the values so obtained yields the semilogarithmic plot of Fig. 2, from which it may be seen that within the limits of $7.5 > (\delta_p - \Delta_o) > 3.5$, the relation between Q and solubility parameter difference is approximately

$$\ln Q = a - k(\delta_p - \delta_o) \qquad (12)$$

where a and k are constants.

* The data in Figs. 1 a–d were obtained as follows: all surface area data were taken directly from the data of Merchant (*6*) or interpolated from surface area-temperature plots of his data. Solubility parameters were calculated at 25°C. by the Hildebrand rule and corrected to other temperatures by application of the Clausius-Clapeyron equation. Solvents used were *n*-pentane, *n*-hexane, cyclohexane, benzene, toluene, acetone, tetrahydrofuran, and ethyl ether. The "wild point" on Fig. 1b is the single observation employing ethyl ether.

Now, the various isothermal expressions shown in Figs. 1, a–d, can be simply represented as

$$A = b - h\delta_o \qquad (13)$$

where b and h are constants. At constant value of δ_p (a condition which holds at constant temperature) this is equivalent to

$$A = b' + h(\delta_p - \delta_o) \qquad (14)$$

Combining equations (12) and (14) yields

$$A = a' - k' \ln Q \qquad (15)$$

Equation (15) is a functional relationship meeting the requirements of the general function expressed in the hypothesis leading to equation (11). If this hypothesis is acceptable, therefore, then there is sound theoretical reason for the relationships plotted in Fig. 1.

To sum up this part of the discussion: the data of Merchant (*6*) on the surface area by nitrogen adsorption of pulps dried from nonpolar solvent, following displacement of alcohol and of water, have been compared with the solubility parameters of the solvents used. If the hypothesis is accepted that the very small amounts of nonpolar solvents taken up by the cellulose polymer at equilibrium serve to plasticize the polymer, then the relationship presented is entirely consistent with thermodynamic solubility theory over the range of solubility parameters studied.

GROSS SWELLING OF CELLULOSE IN POLAR SOLVENTS

With the present state of solubility theory, it is not possible in this case to treat the swelling of cellulose by application of thermodynamic theory as was done in the case presented above. However, the case of polar solvents is sufficiently interesting to warrant inclusion of some empirical observations which have their foundation in thermodynamic reasoning.

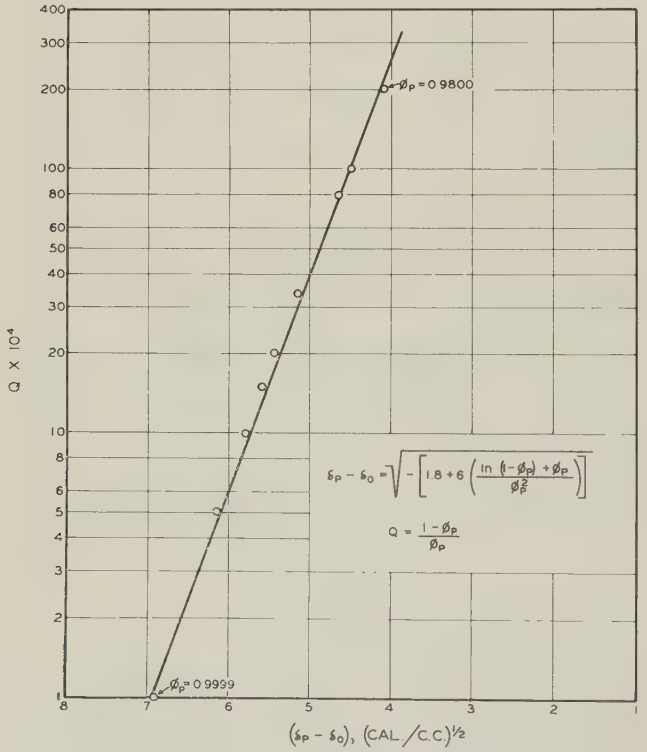

Fig. 2. Derivation of approximate relation between swelling parameter and solubility parameter

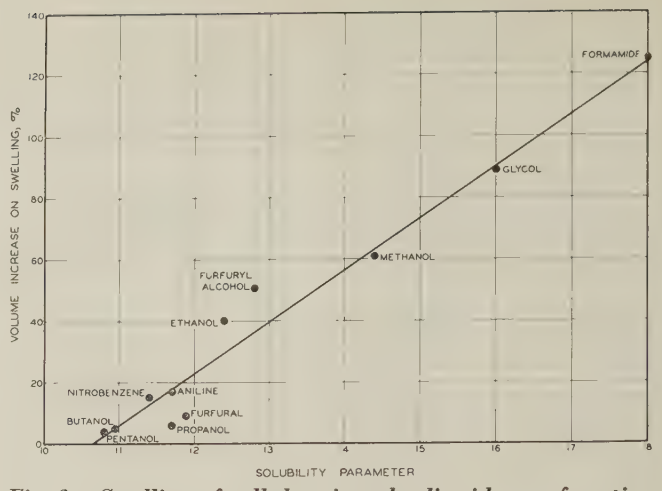

Fig. 3. Swelling of cellulose in polar liquids as a function of a solubility parameter. [Swelling data from Kress and Bialkowsky (4)]

In the early theoretical discussion, the connection of solubility parameter with cohesive energy density was but briefly mentioned. At this point, it is necessary to mention that the cohesive energy density ($\Delta E^V/V$) is no longer represented by δ^2 in liquids where dipole attractions are significant. The solubility parameter concept has been so useful to practical workers in the surface coatings and adhesive fields, however, that various empirical corrections have been devised to permit computation of "apparent solubility parameters" of polar liquids. Approximations such as those suggested by Burrell (*12*) invalidate equations (9) and (10); nevertheless, they permit one to obtain numbers from energies of vaporization and molal volumes. These numbers correlate well with swelling and solubility behavior.

For the purposes of this paper, the apparent solubility parameters of 11 organic liquids used by Kress and Bialkowsky (*4*) in their swelling study were computed according to the method of Burrell (*12*) and compared with the swelling data presented by the former. In Fig. 3 is shown the empirical relation so obtained; the fit of the points with a straight line is really remarkable. In fact, the correlation coefficient is 0.98. It should be pointed out, however, that no connection with theoretical expressions such as equations (3) and (9) can be made in the light of present knowledge.

One major indication derivable from this figure is that the "solubility parameter" of cellulose is not a constant but depends on the solvent in question. The data in Fig. 1 and the expressions derived therefrom indicate that, with relation to nonpolar solvents, cellulose has a solubility parameter of around 14 at room temperature. The data in Fig. 3 are entirely inconsistent with such a value or, for that matter, with any other reasonable, constant value for the solubility parameter of the cellulose polymer. One may speculate that any thermodynamic expression eventually evolved for the swelling of cellulose will have to include some term for the free energy of rupture of hydrogen bonds in the lower-order regions of the polymer.

It should also be pointed out that swelling data for amines do not agree with Fig. 3. Since it is known from x-ray evidence that these solvents penetrate the high-order (crystalline) regions of the fiber, this lack of agreement is understandable.

It is hoped that the relationship displayed in Fig. 3 will stimulate research into the thermodynamic analysis of swelling of cellulose in nonpolar liquids.

CONCLUSION

Computation from published data on the surface area of wood pulps dried from nonpolar solvent after displacement of water shows an inverse relationship between such surface area and the solubility parameter of the final solvent. This relationship is consistent with previously developed thermodynamic theory if it is assumed that the small amount of nonpolar solvent dissolved in the cellulose serves as a plasticizing agent.

Published data on the gross swelling of cellulose in polar solvents show a direct relation between per cent volume increase and solubility parameter of the final solvent. Since δ^2 and $(\Delta E^V/V)$ are not equivalent in this case, thermodynamic theory as presently developed does not apply.

It is much to be hoped that further insight into these phenomena will be sought through experimentation.

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Dimensional Stabilization of Wood by Thermal Reactions and Formaldehyde Cross-Linking

ALFRED J. STAMM

This paper presents results of research on the dimensional stabilization of wood by heat alone, by heat in the presence of a catalyst, and by heat in the presence of both catalyst and formaldehyde vapor. In the thermal reaction, catalysts accelerate the rate but do not affect either the activation energy or the linear relationship between the square of the reduction in swelling and the weight loss. When both an acidic catalyst and formaldehyde vapor are present, dimensional stability develops more rapidly as a result of formaldehyde cross-linking. The square of the reduction in swelling initially increases linearly with time and with the amount of formaldehyde chemically bound. Reductions in swelling of as much as 90% are obtainable with a bound formaldehyde content of 7%. Toughness and abrasion resistance are, however, greatly reduced. These strength reductions can be attributed almost entirely to the heat stabilization reaction that accompanies formaldehyde cross-linking.

STABILIZING the dimensions of wood against swelling and shrinking by drastic heat treatments was at one time believed to result from the formation of ether linkages between adjacent cellulose chains as a result of the loss of water of constitution (*9, 11*). This explanation has more recently been discredited on the basis that wood so heated swells more in dilute alkali or in pyridine than does unheated wood (*5*). If cross bonds were formed, the swelling should be reduced in all swelling agents that are incapable of breaking the ether linkage. The alternate explanation offered is that the more hygroscopic hemicellulose portion of the wood is partially destroyed and some of the products are converted to less hygroscopic polymers that are inert to water but swell in dilute alkali and in pyridine (*5*).

Heat treatments have been shown to reduce the swelling of both wood (*5, 9*) and paper (*8*) to about half the normal amount.

Previous research on the dimensional stabilization of wood by reacting it with formaldehyde vapor had shown that good dimensional stabilization (60 to 70% reduction in swelling) could be obtained with as little as 4% of combined formaldehyde (*14*). To obtain comparable stabilization by acetylation required about 20% of combined acetyl (*13*); and to achieve this level of stabilization by impregnation with phenol formaldehyde resin required a resin content of about 30% (*12*). This high efficiency of formaldehyde in reducing swelling, together with the fact that the reaction reduces the swollen dimensions rather than—as in the case of acetylation (*13*) and resin treatment (*12*)—increasing the dry dimensions, makes it appear that the reaction is one of cross-linking between cellulose chains (*14*). Further, swelling in dilute alkali solution and in pyridine is reduced proportionately as much as in water for both wood (*14*) and paper (*8*).

Unfortunately, this formaldehyde cross-linking reaction takes place only in the presence of an acid catalyst with the result that there is a large loss of toughness and abrasion resistance in the wood (*14*). Gruntfest and Gegliardi (*4*), however, have shown that cross-linking of cotton fabrics with formaldehyde can be carried out as well with salt catalysts as with acid

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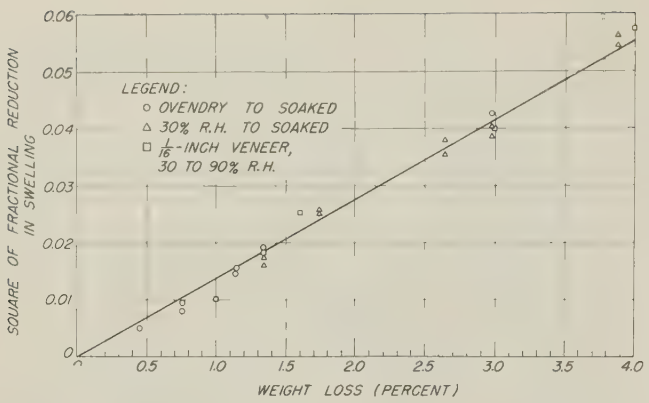

Fig. 1. Relationship between the square of the fractional reduction in swelling and the weight loss of heat-stabilized Sitka spruce. Water-soaked specimens, 0.125 in. thick, containing zinc chloride catalyst. Veneer treated without catalyst

catalysts, and with little apparent embrittlement. Stamm and Cohen (*10*) have shown that a high degree of dimensional stabilization can be imparted to paper by a cross-linking treatment with formaldehyde vapor, with small to moderate embrittlement, when small amounts of zinc chloride are used as catalyst. It thus appeared worth while to determine if cross-linking of wood with formaldehyde vapor and salt catalysts could be accomplished with less embrittlement than occurred with the acid catalysts (*14*).

MATERIALS AND METHODS

Three species of wood, Sitka spruce, Douglas-fir, and redwood, and three types of specimens were used in this research. The Sitka spruce cross sections were cut from a single piece of wood in which the annual rings were relatively flat and parallel to two opposite faces. The sections were 2.25 in. square by 0.125 in. thick in the fiber direction. The Douglas-fir specimens were cut from a single sheet of sliced, edge-grain veneer $^1/_{20}$ in. thick, to dimensions 4.25 in. radially and 3 in. longitudinally of the sheet. Sitka spruce and redwood specimens were cut from single quarter-sawn boards 0.25 in. thick and about 6 in. wide in the radial direction to a length of 1 in. in the fiber direction.

Catalysts were introduced into the wood by immersing the oven-dried specimens in 1% aqueous salt solutions in a vacuum desiccator; air was evacuated until bubbling ceased. When the vacuum was released, and the specimens were kept immersed for several hours, they were then air dried, first at 80% R.H. and finally at 30% R.H. to constant weight. The controls were similarly filled with water and then dried. The different species and sizes of specimens took up different amounts of solution, but those of any one set took up close to the same amount. Catalyst content in general was within 0.05%, either way, of the average value for each set of specimens.

Heat-stabilized specimens were oven-dried to constant weight and then heated in an oven between preheated brass plates for various lengths of time at several fixed temperatures.

The cross-linking with formaldehyde vapor was carried out in a vacuum desiccator inside an oven. An excess of powdered paraformaldehyde was placed in a crystallizing dish under the specimens.

The swelling was determined either between the oven-dry and the water-soaked condition or between equilibrium with 30% R.H. and the water-soaked condition. A vacuum was pulled on the immersed specimens and released to facilitate the attainment of swelling equilibrium. Both the tangential and radial dimensions of the cross sections and radial dimensions of the other specimens were determined with a dial gage to within 0.001 in. The reduction in swelling accomplished by the treatments was determined by subtracting the measured swelling of a heat-stabilized or formaldehyde-treated specimen from that of an unreacted, catalyst-free control and dividing this difference by the swelling of the control.

Abrasion resistance tests were made on the 6 by 1 by 0.25-in. specimens by cutting them into two 2.75 by 1-in. specimens and gluing these side by side on a wood support to give a 2 by 2.75-in. face for abrasion. The tests were made on the Navy abrader (*1*), which combines an impact with a sliding, twisting motion in an attempt to duplicate the movement of the human foot in walking. It operates with fresh aluminum oxide grit no. 80 continuously flowing onto the grinding plate. The loss of thickness was determined at five fixed but arbitrarily chosen points by use of a templet at intervals of 50 rev.

The toughness tests were made on the small Forest Products Laboratory toughness tester (*15*), which measures the work absorbed in breaking the specimen in bending. The specimens were 3 in. long in the fiber direction, 0.25 in. wide, and 0.05 in. deep.

RESULTS OF TESTS

Heat Stabilization

A few tests were made to determine the effect of catalyst and heat alone upon the dimensional stability and abrasion resistance of the wood. Sitka spruce cross sections containing 2.5% of zinc chloride were heated between brass plates for various periods of time at 120, 140, and 180°C. Figure 1 shows that the

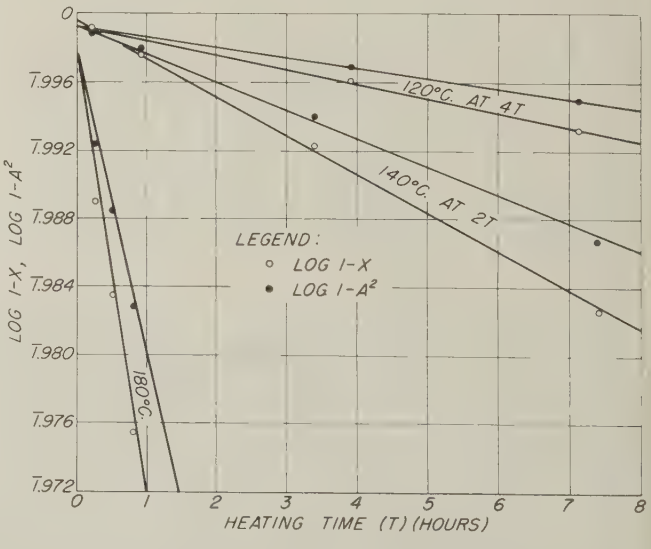

Fig. 2. Relationships between the heating time for heat-stabilized Sitka spruce cross sections containing 2.5% of zinc chloride catalyst and the logarithms of 1 − x and 1 − A_2 (where x is the weight loss and A is the accompanying reduction in swelling), at three treating temperatures. Each point is the average of two determinations. Numbers on curves indicate temperature of stabilization treatment and multiples of time scale

Table I. Activation Energy and Reaction Rate for the Heat Stabilization Reaction of Cellulosic Materials

Cellulosic material	Catalyst	Catalyst concentration (by weight), %	Temperature range, °C.	Activation energy: From weight loss, cal./mole	Activation energy: From reduction in swelling, cal./mole	Reaction rate at 150°C.: From[a] weight loss	Reaction rate at 150°C.: From[b] reduction in swelling
Coniferous woods[c]	None	...	93.5–250	29,500	....	0.00012	....
Insulating fiberboards	None	...	120–180	27,600	....	0.00020	....
Unbleached kraft paper	None	...	100–180	26,700	26,200	0.00022	0.004
Unbleached kraft paper	$ZnCl_2$	1.25	80–200	28,100	27,700	0.010	0.19
Sitka spruce	None	...	160–183	29,000	31,000	0.00012	0.00016
Sitka spruce	$ZnCl_2$	2.5	120–180	28,600	28,000	0.0020	0.0028

[a] Slope of log $(1 - x)$ versus time in hours where x is the fractional weight loss obtained from log of log $(1 - x)/t$ versus $1/T$ plot.
[b] Slope of log $1 - A^2$ versus time in hours where A is the fractional reduction in swelling obtained from log of log $(1 - A^2)/t$ versus $1/T$ plot.
[c] Average for Sitka spruce, Douglas-fir, southern pine, and white pine.

square of the dimensional stabilization obtained by the thermal reaction is proportional to the weight loss, irrespective of whether catalyst is present. The data shown for $^1/_{16}$-in. veneer are from previous work (*9*). A similar linear relationship was recently found for the thermal stabilization of unbleached kraft paper (*8*). In the case of paper, however, the slope of the line is 12 times as steep. The thermal reaction is hence far more favorable for stabilizing the dimensions of paper than for stabilizing the dimensions of wood.

When the logarithm of $1 - x$ (where x is the weight loss) and the logarithm of $1 - A^2$ (where A is the reduction in swelling resulting from the thermal reaction) are plotted against the time of heating for each temperature, initially straight lines are obtained (Fig. 2). The logarithms of these slopes plotted against the reciprocal of the absolute temperature gave straight lines, from which an activation energy of 28,600 cal. per mole was calculated from the weight loss data and of 28,000 cal. per mole from the reduction in swelling data. Table I shows that the catalyst-free Sitka spruce gave similar activation energy values.

Previous determinations of the average activation energy resulting from the thermal reaction for various coniferous woods (*7*) and for different insulating fiberboards from weight loss data are also given in Table I. These values and recent values obtained for kraft paper (*8*) (Table I) indicate that the nature of the cellulosic material and the presence or absence of catalyst has little effect upon the activation energy

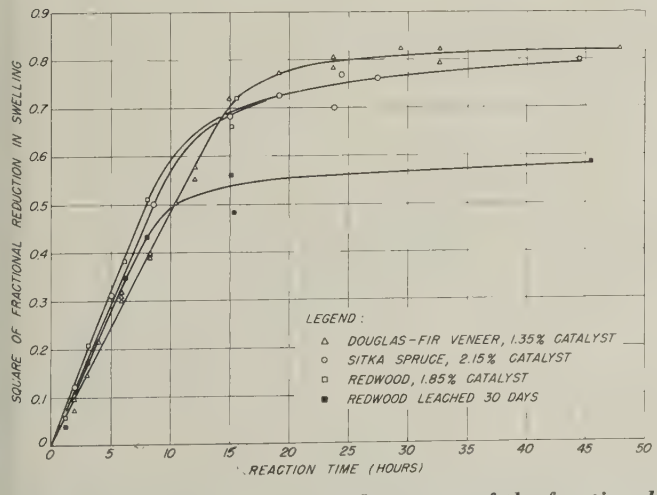

Fig. 3. Relationship between the square of the fractional reduction in swelling and the reaction time for wood cross-linked with formaldehyde in the presence of zinc chloride catalyst

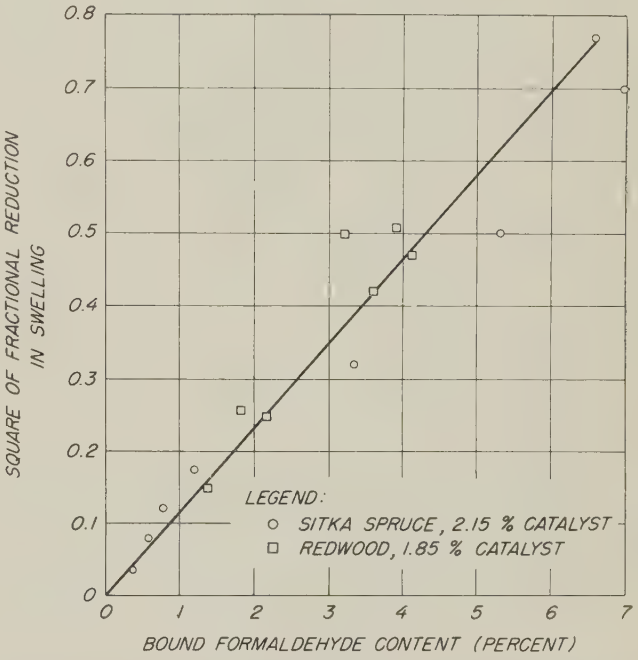
SQUARE OF FRACTIONAL REDUCTION IN SWELLING
BOUND FORMALDEHYDE CONTENT (PERCENT)
LEGEND:
SITKA SPRUCE, 2.15 % CATALYST
REDWOOD, 1.85 % CATALYST

Fig. 4. Relationship between the square of the fractional reduction in swelling and the bound formaldehyde content for 6 by 0.25 by 1-in. Sitka spruce and redwood cross-linked with formaldehyde in the presence of zinc chloride catalyst

of the thermal reaction. The presence of the catalyst, however, increased the rate of the dimension stabilizing reaction for the wood about 17 times, as is shown by the reaction rates in Table I. Table I also shows that only half as much catalyst increased the reaction rate for kraft paper 46 times.

Cross-Linking with Formaldehyde Vapor

The specimens cut from Sitka spruce and redwood lumber and the Douglas-fir veneer specimens that had been impregnated with zinc chloride and dried at 30% R.H. were reacted with formaldehyde vapor generated from paraformaldehyde at 120°C. The square of the resulting fractional reduction in swelling is plotted in Fig. 3 against the reaction time. Linear relationships were obtained up to about a 70% reduction in swelling; thereafter, the reaction slowed down. A final reduction in the swelling of about 90% was obtained, which was considerably higher than any obtained with paper (*8*). It was suspected that paraformaldehyde was condensing in and bulking the wood structure, thus reducing the swelling to a greater extent than by cross-linking alone (*13*).

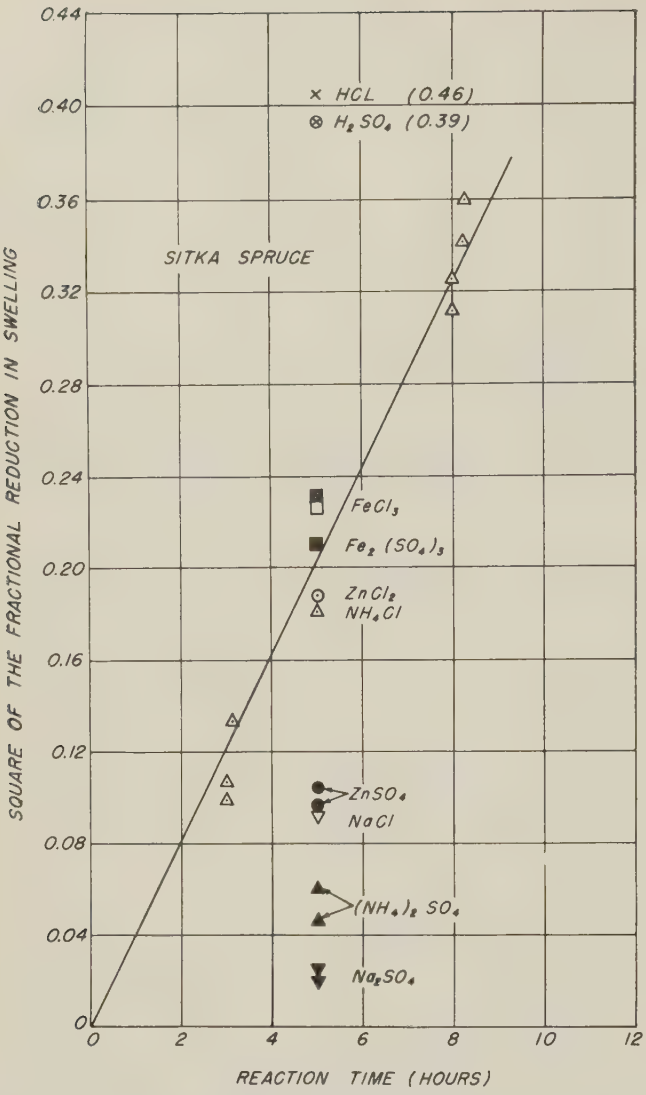

Fig. 5. Relationship between the square of the fractional reduction in swelling and the reaction time for Sitka spruce 6 by 0.25 by 1.0-in. specimens containing 2.30 ± 0.05% of various catalysts

To confirm this suspicion, the treated redwood specimens were filled with water by pulling a vacuum on them while immersed, releasing it, and then soaking them in running water for a month. Weight losses after oven drying were greater for the treated specimens than for untreated controls, indicating that more than the normal amounts of extractives were being removed. The resultant swelling data are also plotted in Fig. 3. The reduction in swelling for the shorter reaction times was only slightly reduced, but for the longest reaction time it was reduced from 90% to 77%.

The Sitka spruce specimens were leached in water for 2 weeks and then dried. Small ground samples of these and the leached redwood specimens were colorimetrically analyzed for bound formaldehyde by the chromotropic acid method (*2*). The values are plotted against the square of the fractional reduction in swelling in Fig. 4. A rough linear relationship was obtained that resembled that obtained for paper (*8*). About seven times as much bound formaldehyde was needed, however, to impart a definite degree of dimensional stabilization to wood as compared with kraft paper.

To determine the effects of other salts as catalysts, 6 by 0.25 by 1.0 in. specimens of Sitka spruce were impregnated with a series of chloride and sulphate catalysts. The average catalyst content was 2.3 ± 0.05%. These were reacted with formaldehyde vapor for various times at 120°C. In Fig. 5 the square of the fractional reduction in swelling is plotted against the reaction time. The catalysts fall in the following order of decreasing effectiveness: H^+, Fe^{+++}, Zn^{++}, NH_4^+, and Na^+ for both chlorides and sulphates, with the former definitely superior to the latter. The order roughly follows the pH of 10% unbuffered solutions of the catalysts in distilled water with a pH of 5.7 (0.3 for the hydrochloric acid to 5.2 for the sodium sulphate). These concentrations are lower than those attained in the wood at 30% R.H. This, combined with any buffering action of the wood, would make any close correlation seem fortuitous.

A similar series of measurements was made with formates and acetates of all of the cations except iron as catalysts. Formic acid gave a reduction in swelling of only 9% and zinc formate only 7% for the 5-hr. reaction at 120°C. Ammonium and sodium formates and all of the acetate series gave negligible stabilization values.

Effects on Strength

Toughness tests were made on the Douglas-fir veneer cross-linked with formaldehyde. The toughness relative to that of the untreated control is plotted in Fig. 6 against the reduction in swelling caused by the treatment. Each point represents the average of 10 measurements. The toughness drops off rapidly as the dimensional stability increases to less than one tenth of the original value.

Abrasion resistance tests were made on the heat-stabilized Sitka spruce (with and without catalyst) and on the Sitka spruce cross-linked with formaldehyde. Figure 7 gives the abrasion resistance relative to untreated controls plotted against the reduction in swelling for the average of two specimens. In all cases, a large reduction in abrasion resistance occurs even at

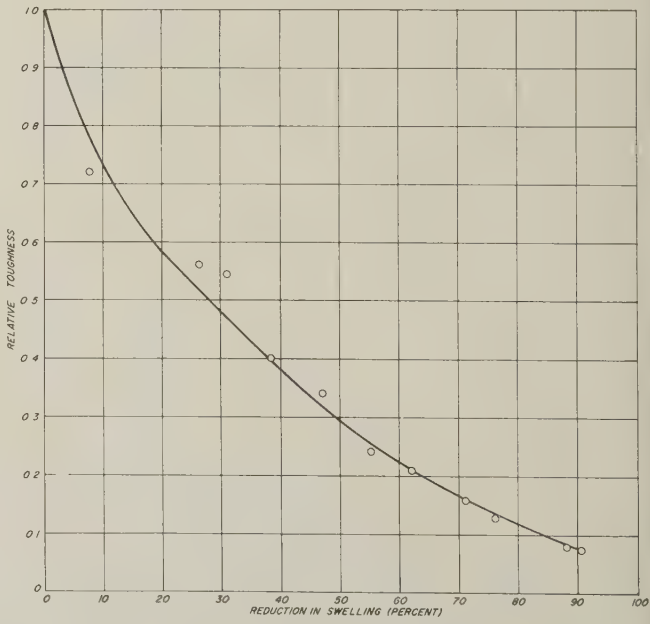

Fig. 6. Relationship between the toughness, relative to that of the untreated controls, and the reduction in swelling for Douglas-fir veneer cross-linked with formaldehyde and containing 1.35% of zinc chloride catalyst

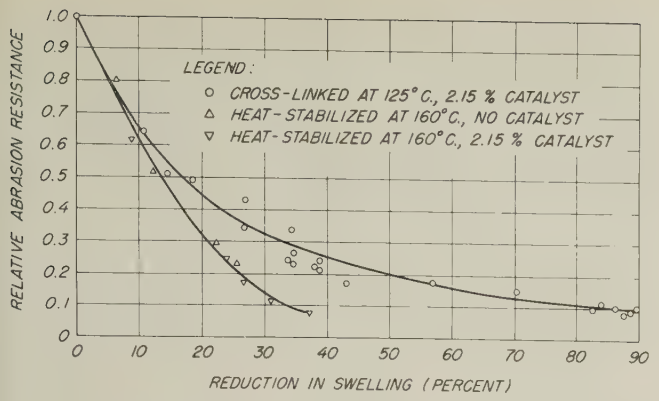
RELATIVE ABRASION RESISTANCE
REDUCTION IN SWELLING (PERCENT)
LEGEND:
CROSS-LINKED AT 125°C., 2.15 % CATALYST
HEAT-STABILIZED AT 160°C., NO CATALYST
HEAT-STABILIZED AT 160°C., 2.15 % CATALYST

Fig. 7. Relationship between the abrasion resistance, relative to that of the untreated controls, and the reduction in swelling for heat-stabilized Sitka spruce with and without formaldehyde cross-linking and treatment with zinc chloride catalyst

relatively low levels of dimensional stabilization. The loss in abrasion resistance is, however, less drastic for the cross-linked specimens than for the heat-stabilized specimens. The cross-linked specimens of redwood gave values very similar to those for the cross-linked Sitka spruce.

It is of interest that the data for heat stabilization fall on a single curve irrespective of whether catalyst is present or not. Apparently, the development of dimensional stability and the loss in abrasion resistance are parallel functions of the extent of the thermal reaction. The presence of the catalyst merely accelerates the rate of this reaction. This is shown in Fig. 8. The heat stabilization reaction, which is slower than the cross-linking stabilization reaction was carried out at 160°C. To put the heat stabilization curves on a comparable basis with the cross-linking curve, calculated dashed curves are included in Fig. 8 in which the heat stabilization data at 160°C. were transposed to 120°C. values, using the temperature coefficients calculated from the data of Fig. 2. It is of interest that, at the same temperature and catalyst content, the heat stabilization and the formaldehyde cross-linking reactions when carried on for the same length of time cause the same reduction in abrasion resistance. This indicates that the loss in strength can be almost entirely attributed to the heat stabilization reaction that accompanies the formaldehyde cross-linking reaction.

Figure 9 gives the relationship between the relative abrasion resistance and the reduction in swelling ob-

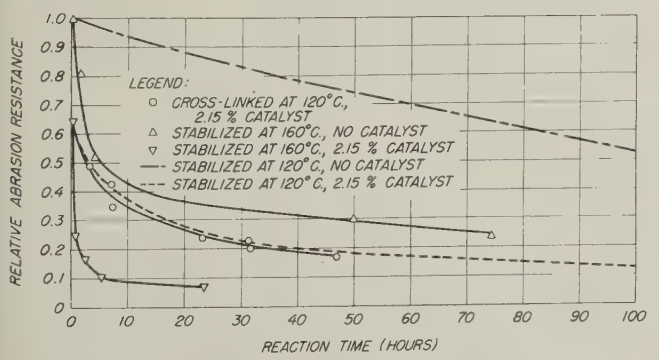
RELATIVE ABRASION RESISTANCE
REACTION TIME (HOURS)
LEGEND:
CROSS-LINKED AT 120°C., 2.15 % CATALYST
STABILIZED AT 160°C., NO CATALYST
STABILIZED AT 160°C., 2.15 % CATALYST
STABILIZED AT 120°C., NO CATALYST
STABILIZED AT 120°C., 2.15 % CATALYST

Fig. 8. Relationship between the abrasion resistance, relative to that of the untreated controls, and the reaction time for heat-stabilized Sitka spruce with and without formaldehyde cross-linking and treatment with zinc chloride catalyst. Dashed lines represent calculated values

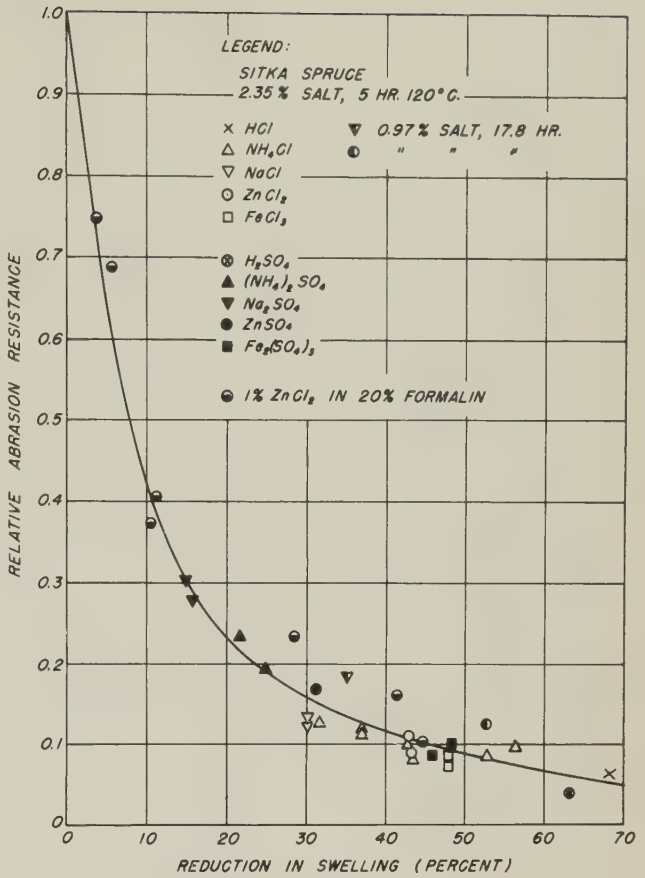

Fig. 9. Relationship between the abrasion resistance, relative to that of the untreated controls, and the reduction in swelling for formaldehyde cross-linked Sitka spruce specimens (6 by 0.25 by 1.0 in.) containing 2.30 ± 0.05% of different catalysts. Data are also included for specimens treated with various amounts of a 1% solution of zinc chloride in 20% formalin followed by drying at 120°C. for 1.5 to 2.5 hr.

tained when various catalysts are used in the cross-linking treatment with formaldehyde. The figure shows that nothing is gained from the standpoint of loss in relative abrasion resistance by using less degradative catalysts. When the loss in abrasion resistance is reduced, the dimensional stabilization is likewise reduced according to the same exponential relationship. Data are also included in Fig. 9 to show that soaking specimens in a formalin-catalyst solution, followed by drying and reaction with formaldehyde (*8*), gave no improvement in the relation between abrasion resistance and reduction in swelling.

CONCLUSIONS

Dimensional stabilization can be imparted to wood by a heat stabilization treatment alone or together with a formaldehyde cross-linking reaction.

The heat stabilization reaction takes place with or without a catalyst with an activation energy of about 28,000 cal. per mole. Catalysts, however, greatly increase the rate of the reaction. Wood containing 2.5% of zinc chloride catalyst develops dimensional stability from the thermal reaction about 17 times as fast as does catalyst-free wood. The square of the resulting reduction in swelling is proportional to the weight loss occurring during the reaction. The abrasion resistance of wood is greatly reduced by the thermal reaction. The same loss in abrasion resistance occurs for wood

heated with or without a catalyst when heating is continued in each case for a period of time that will give the same degree of dimensional stability.

The formaldehyde cross-linking reaction takes place only in the presence of an acidic catalyst and heat. The square of the resulting reduction in swelling is, initially, directly proportional to time and to the amount of formaldehyde that is chemically bound. Reductions in swelling as great as 90% have been attained with as little as 7% of bound formaldehyde, but the reaction greatly reduces the toughness and abrasion resistance of the wood. It is shown that the thermal degradation caused by catalyst and heat alone accounts for practically all of the loss in abrasion resistance. Use of milder catalysts does not look hopeful, because reductions in the strength losses in this way result in reduced dimensional stabilization as well.

Some loss in toughness is acceptable for certain uses of wood. For example, laminates made from veneer treated with fiber-penetrating phenol formaldehyde resin, which are used for making die models for automobiles (*6*), have a toughness about half that of the untreated laminates (*3*). The loss in toughness accompanying a reduction in swelling of 30 to 40% might be tolerated for some uses. It is questionable, however, if uses could be found for wood where the toughness is reduced to one tenth of normal. The same appears true for abrasion resistance.

The principle of dimensional stabilization by cross-linking reactions appears sound and economical when the molecular weight of the cross-linking agent is low. Cross-linking reactions obtained with other agents of low molecular weight may have less detrimental effect upon the strength properties of wood.

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Dimensional Stabilization of Paper by Catalyzed Heat Treatment and Cross-Linking with Formaldehyde

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When paper is heated under controlled conditions, a reaction takes place that develops permanent dimensional stability. Swelling of paper can be reduced in this way by 60%. The necessary time of heating to attain a definite degree of stabilization increases logarithmically with decrease in temperature. Unbleached kraft paper containing 1.25% of zinc chloride develops dimensional stability, when heated at a fixed temperature, about 46 times as fast as when no catalyst is present. The activation energy for the reaction with the zinc chloride catalyst present is 28,000 cal. per mole. This is practically identical to the values obtained when catalyst-free insulating board and coniferous woods are heated. When paper containing the zinc chloride catalyst is heated in an atmosphere of formaldehyde vapor, dimensional stability develops more rapidly as a result of cross-linking. This reaction has an activation energy of 19,000 cal. per mole. Reductions in swelling as great as 80% have been attained. Strength tests on the paper show that reductions in swelling up to 40% can be attained on the heat stabilized sheets and of 60% on formaldehyde cross-linked sheets without excessive embrittlement.

THE fact that paper swells to an appreciable degree when exposed to high relative humidities is of relatively little importance for most of its uses. There are, however, a number of special uses where dimensional stability is of prime importance as in papers for multicolor printing, maps, shop drawings, and punch cards. In spite of this importance there is relatively little available information on the nature of the swelling of paper and how it might be controlled.

The author (*6*) has shown that the swelling of paper is not only dependent upon the reversible swelling of the fibers themselves but also upon accompanying separation or dispersion of the fibers. The dry strength of ordinary paper is so many times greater than the wet strength that standard test methods cannot be applied to the latter. Wood, on the other hand, swells without dispersion of the structural units and has a dry strength only two to four times that of green wood (*14, 17*). This, it is believed, results from the breaking of far more bonds between the structural units in paper than those in wood. Under such conditions, the plasticized fibers of paper tend to relax and straighten out, thus increasing the volume.

Another reason for believing that a certain amount of fiber separation or dispersion occurs when paper swells is the fact that papers show a greater volumetric swelling than is theoretically possible as a result of swelling of the fibers alone. This is illustrated in Fig. 1, in which the volumetric swelling of various papers is plotted against the specific gravity of the dry paper.

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The open numbered points are for machine-made papers. The corresponding shaded points represent the swelling of the same papers after presoaking in water and air drying without restraint. In all cases the second-cycle swelling is less than that of the first because the first cycle includes springback from pent-up stresses.

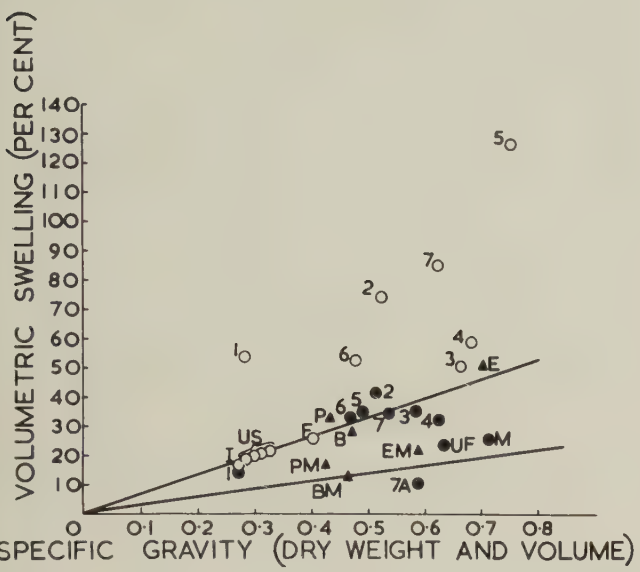

Fig. 1. Volumetric swelling of various papers in relation to their specific gravity based on weight and volume when dry

Numbered open circles, filler-free papers made on the U. S. Forest Products Laboratory experimental Fourdrinier machine. Numbered shaded circles, same papers after stress was relieved by water-soaking them and drying between blotters. Shaded triangles, stress-relieved papers. 1, bleached southern pine sulphate, no beating; 2, unbleached southern pine sulphate, no beating, calendered; 3, unbleached jack pine sulphate, lightly beaten; 4, unbleached eastern hemlock modified neutral sulphite, beaten, calendered; 5, unbleached aspen neutral sulphite semichemical, lightly beaten, calendered; 6, unbleached aspen cold soda, unbeaten, calendered; 7, bleached aspen neutral sulphite semichemical, unbeaten; I, commercial insulating board, coated face removed; F, commercial filter paper; US, "unit sheet" handsheets approximately two fibers thick; E, bleached eucalyptus sulphate, mildly beaten handsheets; P, unbleached Swedish pine sulphate, mildly beaten handsheets; B, commercial evaluation blotters; UF, urea-formaldehyde wet-strengthened commercial sulphite paper; M, melamine-formaldehyde wet-strengthened commercial sulphite paper; EM, PM, and BM, melamine-resin wet-strengthened papers; A, acetylated.

The difference between the swelling for the corresponding open and shaded points thus represents the irreversible dispersion part of the swelling.

The swelling of the stress-relieved sheets and the original sheets, made under such slight restraint that a significant amount of pent-up stress could not be created, such as insulating board and "unit sheets" (*2*), all fall reasonably close to the upper straight line of Fig. 1. The lower straight line represents the theoretical swelling that would occur if caused entirely by fiber swelling with no separation of the fibers. This line has about half the slope of the upper line. In general, the actual swelling of untreated stress-free papers is about twice that due to fiber swelling. The difference between the two lines must thus represent the reversible dispersion part of the swelling.

Papers wet strengthened with synthetic resins in general fall just above the lower straight line of Fig. 1, which indicates that most of the swelling results from fiber swelling and that reversible dispersion has been practically eliminated by the permanent resin bonds between many of the fibers. As most of the dispersion occurs in the thickness direction of paper, wet-strengthening agents are effective in stabilizing the thickness. It has been shown, however, that wet-strengthening resins have a negligible effect in stabilizing paper in the sheet direction (*10*).

The swelling of stress-relieved oven-dry paper at different relative humidities in both the thickness and sheet directions has been shown to be proportional to the water adsorption (*10*). This proportionality would be expected if all of the swelling was fiber swelling. The fact that it holds for total reversible swelling indicates that dispersion is proportional to fiber swelling.

It has been shown that impregnation with polyethylene glycols greatly reduces the swelling of paper (*10*) and of wood (*8*) by a bulking action. This is similar to stabilizing paper by the Upson Co. process (*3, 15*). The swelling of paper has been moderately reduced by cyanoethylation and to a greater degree by acetylation and formaldehyde cross-linking (*11*). The latter appeared to show considerable promise as a means of commercially treating paper to make it more dimensionally stable and to improve wet-strength properties. This research was hence conducted to learn more about the nature of the treatment and determine more definitely the industrial possibilities of the process for treating specialty papers.

MATERIALS AND PROCEDURE

All of the measurements were made on an unbleached kraft paper, with a weight of 110 lb. per ream, made from a northern pine pulp on the Forest Products Laboratory experimental fourdrinier machine without size or filter. The paper was cut into 10.5 by 8-in. sheets.

The zinc chloride catalyst used almost entirely in this research was introduced into the paper by soaking each sheet for 20 sec. in a 1% solution of the salt to which a few drops of hydrochloric acid had been added to remove turbidity. The sheets were then pressed between blotters and air dried at 65% R.H. in brass frames. The takeup of solution was about 125%, re-

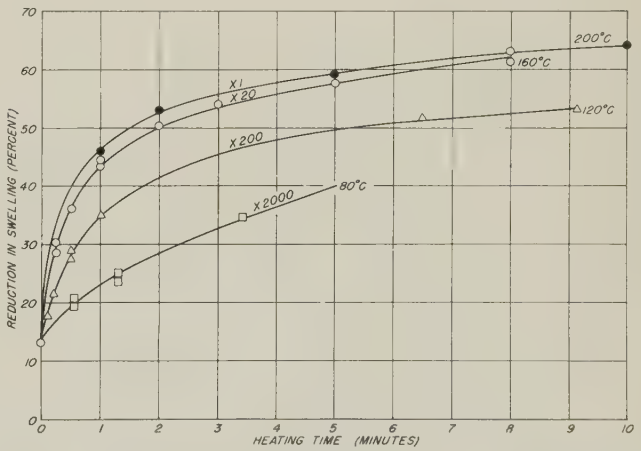

Fig. 2. Reduction in swelling resulting from heating an unbleached kraft paper containing 1.25 ± 0.05% of zinc chloride catalyst between brass plates for different periods of time at four different temperatures. Numbers on curves indicate multiples of time scale

sulting in a catalyst content of the paper 1.25 ± 0.05%.

In the heat-stabilization studies, sheets of paper containing the zinc chloride catalyst were placed in an oven between brass plates preheated to about 2°C. above the desired temperature. As soon as the temperature of the oven recovered, it was set back to hold the desired temperature and the sheets were heated for various lengths of time.

In the formaldehyde cross-linking studies, paper containing the zinc chloride was treated with formaldehyde vapor under three different conditions: (1) in a glass desiccator within an oven over an excess of paraformaldehyde alone or paraformaldehyde suspended in a sulphuric acid solution of such a concentration as to give the desired relative humidity; (2) the same as condition (1), except that the treatment was carried out in a vacuum oven of the type used inside of an ordinary drying oven; and (3) passing humidified air through paraformaldehyde suspended on glass wool and then through five sheets of paper in series clamped with gaskets between brass drying frames inside an oven.

Strips of the treated papers, together with untreated controls about 7 in. long in the across the machine direction by 0.5 in. wide, were soaked in water overnight to relieve drying stresses and then dried to equilibrium moisture content in an atmosphere of 30 % R.H. The length of the strips was measured with a steel rule to within 0.005 in. under a magnifying lens. The strips were then soaked in water overnight and again measured. The swelling was calculated in terms of the reduction in swelling; that is, the swelling

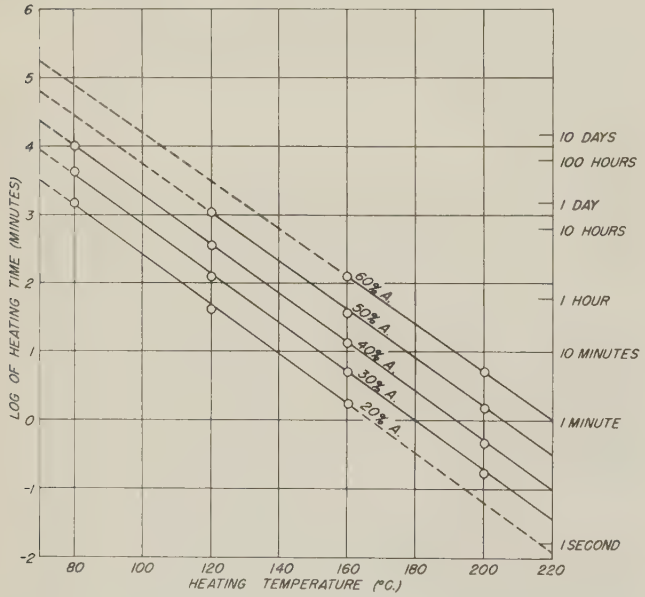

Fig. 3. Relation between logarithm of heating time and heating temperature for several reductions in swelling, A, calculated from data of Fig. 1

of the control minus the swelling of the treated paper divided by the swelling of the control.

HEAT STABILIZATION

A series of measurements was made to determine the effect of the zinc chloride catalyst and heat alone.

In Fig. 2, the reduction in swelling of the heated paper relative to that of the unheated controls between equilibrium with 30% R.H. and the water-soaked condition is plotted against the heating time at four different temperatures. The zinc chloride treated paper, after drying for several days at 26.7°C. and 30% R.H., developed from 11 to 14% of dimensional

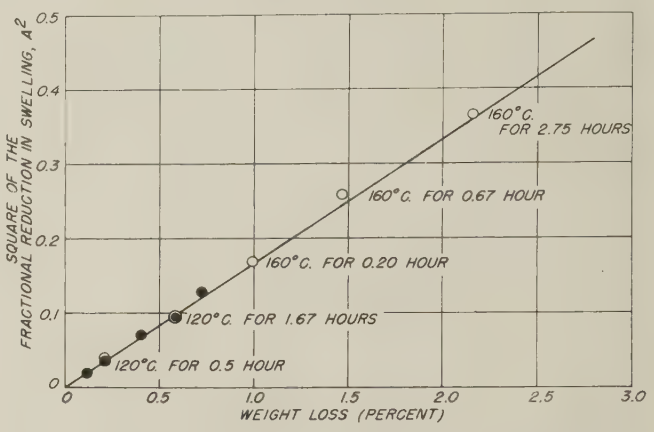
SQUARE OF THE FRACTIONAL REDUCTION IN SWELLING, A²
WEIGHT LOSS (PERCENT)
160°C. FOR 2.75 HOURS
160°C. FOR 0.67 HOUR
160°C. FOR 0.20 HOUR
120°C. FOR 1.67 HOURS
120°C. FOR 0.5 HOUR

Fig. 4. Relationship between the square of the fractional reduction in swelling and the weight loss resulting from heating unbleached kraft paper

Open points—paper containing 1.25 ± 0.05% $ZnCl_2$ catalyst. Shaded point—no catalyst.

stabilization, hence the curves do not pass through the origin. The reduction in swelling appears to decrease exponentially with time of heating. This is verified by Fig. 3, in which the logarithm of the heating time, when plotted against the temperature data, yields a straight line for each reduction in swelling, A. Similar plots were obtained for uncatalyzed heat stabilization of paper, the only difference being that the time to attain any definite reduction in swelling was increased 46-fold.

Figure 4 shows that the weight loss of the paper due to heating is proportional to the square of the fractional reduction in swelling, A^2. The presence or absence of catalyst does not affect this relationship. When the logarithms of $1 - x$ (where x is the weight loss) and $1 - A^2$ are plotted against the time, initially straight lines are obtained. In the case of the reduction in swelling relationship above an A value of 0.45, the change in log $1 - A^2$ per unit of time is greatly decreased. At this value of A, Seborg, Tarkow, and Stamm (*5*) found that a change occurs in the relation of weight loss to reduction in swelling for wood, indicating some change in the nature of the reaction. When the logarithms of the slopes of the linear portions of the curves for log $(1 - A^2)$ versus time and log $(1 - x)$ versus time are plotted against the reciprocal of the absolute temperature, straight lines are obtained, indicating that the heat stabilization initially involves an activated reaction. The activation energy calculated from the weight loss was 28,100 cal. per mole and that from the swelling 27,700 cal. per mole. Similar heat stabilization measurements on paper containing no catalyst gave 26,700 cal. per mole from weight loss data and 26,200 cal. per mole from swelling data. Previous measurements on coniferous woods containing no catalyst gave an energy of activation from weight loss on heating of 29,500 cal. per mole (*7*). Forest

Table I. Cross-Linking of Kraft Paper with Formaldehyde Vapor

Treating method	Catalyst	Catalyst concentration, %	Relative humidity, %	Reaction rate[a] 100°C.	120°C.	150°C.	Activation energy, cal. per mole
Penetrating pack	$ZnCl_2$[b]	1.25	0	0.078	0.29	...	19,200
Penetrating pack	$ZnCl_2$	1.25	70	0.070	0.26	...	19,200
Vacuum oven	$ZnCl_2$	1.25	12	0.046	0.17	...	19,100
Vacuum oven	$ZnCl_2$	1.25	40	0.044	0.17	...	19,700
Vacuum oven	$ZnCl_2$	1.25	70	0.058	2.22	...	19,200
Vacuum oven	$ZnCl_2$	1.25	88	0.016	0.066[b]	...	18,800
Desiccator	$ZnCl_2$	1.25	12	0.052	0.19	...	18,900
Desiccator	$ZnCl_2$	1.00[c]	0	...	0.20	1.1	18,800
Desiccator	NaCl	1.05[c]	0	...	0.09	0.5	19,000

[a] Slope of square of fractional reduction in swelling-time relationship.
[b] Temperature 122°C.
[c] Catalyst introduced into the paper at the size press of the paper machine.

Products Laboratory data on two commercial insulating boards, from which the coated faces were removed, gave an average value for energy of activation from weight loss of 27,600 cal. per mole. It thus appears that the energy of activation for the first part of the reaction resulting from heating of different cellulosic materials, including wood, does not vary greatly and that the presence of catalysts may greatly accelerate the rate of this reaction without changing the activation energy.

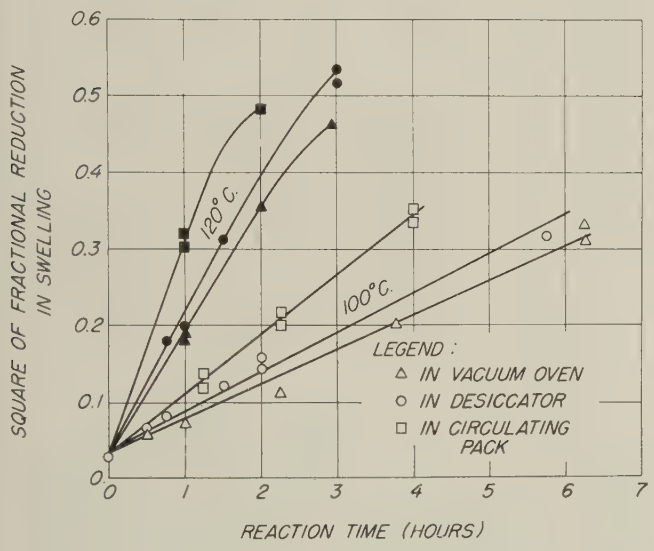

Fig. 5. Relationship between the square of the fractional reduction in swelling and the reaction time for the vapor phase cross-linking of unbleached kraft paper with formaldehyde at 12% R.H.

CROSS-LINKING WITH FORMALDEHYDE VAPOR

The paper containing 1.25 ± 0.05% of zinc chloride catalyst was treated with formaldehyde vapor as shown under Methods and Procedure. In Fig. 5, the square of the fractional reduction in swelling for the three different methods is plotted against the reaction time at two temperatures. Straight lines are obtained up to a reduction of about 0.6 in fractional swelling A. The cross-linking reaction takes place most rapidly in the circulating pack system, presumably because the formaldehyde vapor is brought into better contact with the interior of the paper when the gas is made to pass through the five sheets of paper in series under a slight pressure. No consistent variation in reduction in swelling was noted between the first and the fifth sheet of paper in a series. The rate of reaction was slightly greater in the glass desiccator than in the metal vacuum oven. A similar difference has been previously observed for the cross-linking of wood with formaldehyde vapor in glass and stainless steel containers (*13*).

Similar measurements were made with papers conditioned at 0, 40, 70, and 88% R.H. The rate of development of dimensional stability does not vary appreciably with relative humidity up to about 70% R.H. (Table I). At 88% R.H., dimensional stabilization occurs considerably more slowly. A single run made with sodium chloride as catalyst shows that it takes 2.2 times as long to obtain a definite degree of dimensional stability as when zinc chloride is used as the catalyst. A similar ratio of rates of reaction was obtained with Sitka sprucewood (*9*).

The activation energy of the cross-linking reaction does not vary significantly with the different methods of carrying on the reaction, the relative humidity at which the reaction is carried out, and the nature of the catalyst (Table I). The average activation energy is about 19,000 cal. per mole. The activation energies were calculated on the basis of a constant formaldehyde vapor concentration. If a correction is made for the reason that the increase in formaldehyde concentration with temperature is proportional to the vapor pressure

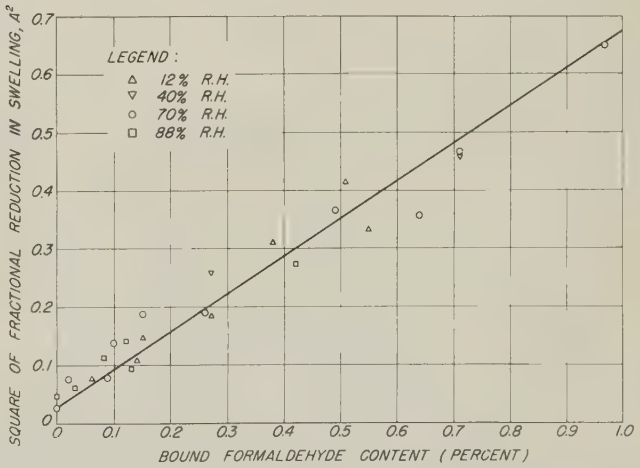

Fig. 6. Relationship between the square of the fractional reduction in swelling and the bound formaldehyde content of unbleached kraft paper cross-linked with formaldehyde vapor at different relative humidities

Table II Comparison of the Reduction of Swelling Obtained When Formaldehyde Cross-Linked Paper Originally in Equilibrium with 30 % Relative Humidity Is Swollen in Water, Pyridine, and Sodium Hydroxide Solution

Paper	Water		Pyridine		2% sodium hydroxide	
	Swelling, %	A.[a] %	Swelling, %	A.[a] %	Swelling, %	A.[a] %
Highly reacted	1.16	73.3	0.94	76.8	1.28	74.3
Medium reacted	2.47	43.0	2.32	42.3	2.86	42.7
Control	4.33	...	4.02	...	4.98	...

[a] Reduction in swelling.

at each temperature according to the values given by Walker (*16*) and it is assumed that the rate of reaction is proportional to the concentration, the activation energy is reduced to about 13,000 cal. per mole. This low value indicates that the reaction may be controlled by the rate of diffusion of formaldehyde vapor into the walls of the fibers.

Figure 6 gives the relationship between the square of the fractional reduction in swelling and the amount of formaldehyde chemically bound. The sheets used for the bound formaldehyde analysis were soaked in a large volume of water over the weekend to remove any condensed paraformaldehyde. They were dried and then hydrolyzed overnight at room temperature in 12 *N* H_2SO_4, and the amount of formaldehyde freed was determined colorimetrically with chromotropic acid (*1*). The fact that the square of the reduction in swelling is proportional to the bound formaldehyde content (Fig. 5) and the square of the fractional

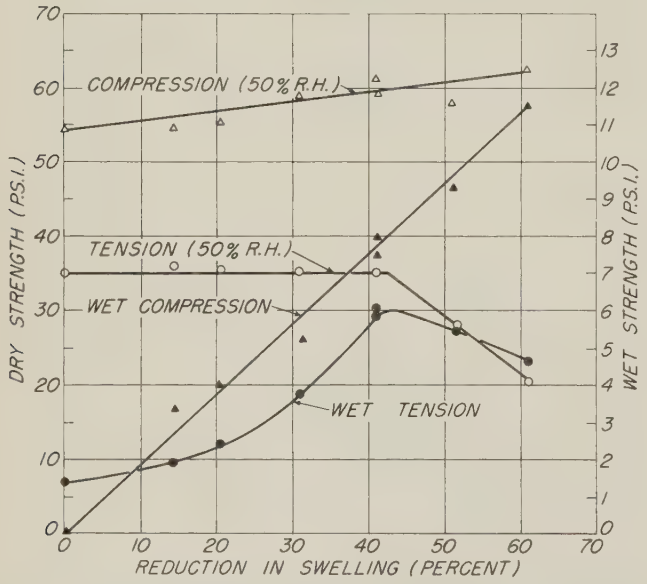

Fig. 7. Relationship of the tension and ring compression properties across the machine direction of heat stabilized unbleached kraft paper containing 1.25 ± 0.05% $ZnCl_2$ catalyst to the reduction in swelling. Wet strengths determined after 48-hr. water soak

reduction in swelling is initially proportional to time (Fig. 4) indicates that the binding of formaldehyde should initially be proportional to time. This was found to be the case by Woo, Dusenbury, and Dillion (*18*) for the reaction with fabrics in the presence of a large excess of formaldehyde. The data indicate that the first few cross-links formed are more effective in reducing swelling than are subsequent cross-links. Figure 6 shows that only 0.35% of formaldehyde has to be bound to reduce swelling to one half of normal.

Paper strips cross-linked with formaldehyde were brought to equilibrium at 30% R.H., measured and then swollen in water, pyridine, and a 2% solution of sodium hydroxide. The actual swelling and the reduction in swelling relative to that of untreated controls are given in Table II. All of the strips swelled less in pyridine and more in the sodium hydroxide solution than in water. The reduction in swelling relative to the control was, however, the same in each liquid. This is good evidence that cross-linking had occurred,

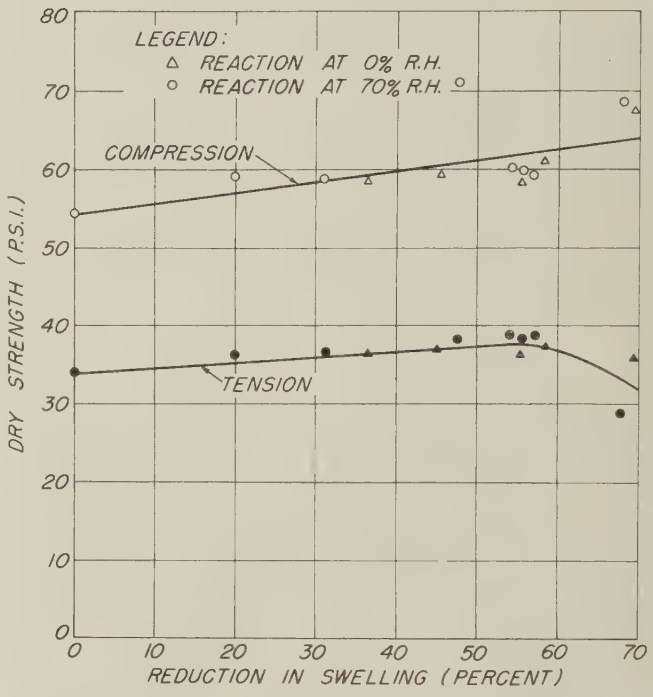

Fig. 8. Relationship of the dry tension and ring compression properties in the cross-machine direction of formaldehyde cross-linked unbleached kraft paper containing 1.25 ± 0.05% $ZnCl_2$ catalyst to the reduction in swelling

as none of these liquids should break the cross-links. Hydrochloric acid was, however, shown to break the cross-links. Strips of the highly reacted paper listed in Table II were soaked for 3 days in a 5% solution of hydrochloric acid at room temperature, washed, dried, and measured again for swelling. The reduction in swelling dropped from 73.3 to 56.4%. Similar strips soaked in a 10% solution of hydrochloric acid at 35°C. for a day dropped to 44.3%. This drop would be expected, as hydrochloric acid is known to hydroylze acetal linkages by means of which the cross-links are believed to form between formaldehyde and cellulose.

The swelling data indicate that the dimensional stabilization must result from cross-linking between the various structural units. This is further supported by the fact that large degrees of dimensional stability are obtained with small amounts of chemical. It is also supported by the fact that this treatment reduces swelling by cutting down on the swollen dimensions (*13*). Treatments that reduce swelling by bulking have been shown to do so by increasing the dry dimensions (*12*).

LIQUID PHASE REACTION WITH FORMALDEHYDE

Strips of the kraft paper were dipped in a 20% solution of formalin containing 1% of zinc chloride for 20 sec. and blotted. The takeup of solution was practically the same as that of a 1% $ZnCl_2$ solution alone. The strips were heated between brass plates for 25 min. to 3 hr. ar 100°C. and 5 min. to 2 hr. at 120°C. All specimens were dry when removed from the oven. Straight lines obtained by plotting the square of the fractional reduction in swelling against time were similar to those given in Fig. 5, with a slope of 0.08 at 100°C. and of 0.34 at 120°C. These gave an activation energy value of 20,500 cal. per mole.

The experiment was repeated using 10.5 by 8-in. sheets of paper. The paper heated for the shorter periods of time was still quite moist near the center when removed from the oven. Strips cut from the wet portion of the sheets swelled slightly more than the controls, indicating a slight negative dimensional stabilization. Strips cut from the dry edges showed some dimensional stabilization but less than the corresponding heated strips. When the treated sheets were heated in the oven in the drying frames, they dried completely and gave stabilization values comparable with those for the heated strips.

Treated sheets were placed between brass plates, and the assembly was put inside a double-walled polyethylene bag to avoid loss of water and then heated for 2 hr. at 100°C. The wet, heated sheets gave a slight negative dimensional stabilization. If they had been allowed to dry while heating, they would have given a fractional reduction in swelling of about 0.40. It is thus apparent that the stabilization reaction takes place only after the paper is reasonably dry. This is not surprising, since formaldehyde reacts with water to form methylene glycol, which exhibits different properties from gaseous formaldehyde (*16*). Then, too, the structural units of cellulose in the paper are too far apart in the presence of free water to bridge the distance between hydroxyl groups on adjacent cellulose chains with formaldehyde.

Crease resistance and dimensional stability have been imparted to fabrics by dipping them in an aqueous formaldehyde solution containing a catalyst and then drying under heat (*4*). It has been claimed that the treatment is not used commercially to any great extent because of the variability of the results. Such variability is not surprising in the light of these present findings, as variations in the heating conditions can vary the amount of formaldehyde retained or reacted according to variations in the rate of drying.

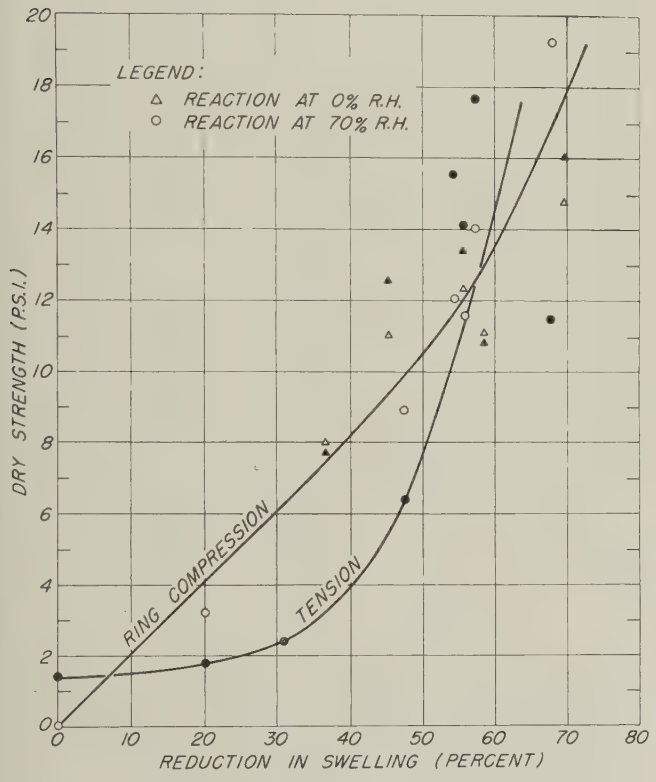

Fig. 9. Relationship between the wet strength properties in the cross-machine direction of formaldehyde cross-linked, unbleached kraft paper containing 1.25 ± 0.05% $ZnCl_2$ catalyst and the reduction in swelling. Strengths determined after 48-hr. water soak

STRENGTH PROPERTIES

Figure 7 gives the relationship between the tensile and ring-compression strength of the heat-stabilized paper, both dry and after soaking 48 hr. in water, and its reduction in swelling. Each point represents the average of two specimens from each of five sheets. The dry tensile strength is unaffected by heat stabilization up to a reduction in swelling of about 40%, beyond which it decreases. The wet tensile strength builds up from practically a negligible value to one sixth of the dry strength at a 40% reduction in swelling. For higher reductions in swelling, it too drops off. The

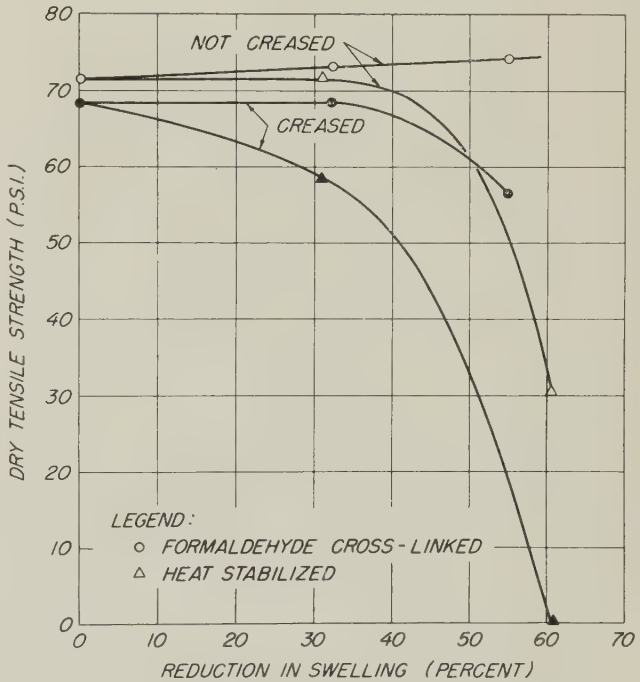

Fig. 10. Relationship of the dry tensile strength in the machine direction of unbleached kraft paper containing 1.25 ± 0.05% $ZnCl_2$ catalyst to the reduction in swelling

ring compression strength of the dry paper increases slightly over the whole range of dimensional stability. Likewise the ring compression strength of the wet paper increases over the whole range from zero to one fifth of the dry value. The increase in both wet tensile and ring compression strength is comparable to the increases obtained by treating the paper with 6 to 8% of phenol formaldehyde resin.

The paper becomes significantly embrittled with increasing treatment, as is indicated by the feel. The loss in tensile strength at reductions in swelling above 40% is obviously due to this embrittlement, as the tensile strength is well known to be reduced by concentrations of stresses, which increase with embrittlement. Compressive strength is not affected by embrittlement, hence the lack of a break in the curves for this property.

Figure 8 gives the relationship between the tensile and ring compression tests in the cross-machine direction and the reduction in swelling for dry paper cross-linked with formaldehyde vapor. In both cases, the strength values increase slightly with an increase in the reduction in swelling. Tensile strength reaches a maximum at about 60% reduction in swelling, whereas the ring compression strength shows no maximum. The relative humidity at which the treatment was carried out seems to have no effect upon the strength. Figure 9 gives corresponding strength values for wet paper. In both cases, the strength increases greatly with an increase in reduction in swelling. No maxima are attained. Wet-strength values equal to those obtained by incorporating 10% of phenol formaldehyde resin in the paper are attained.

Embrittlement seems to play a lesser roll in formaldehyde cross-linked paper than in heat-stabilized paper. This is not surprising, as the reaction time needed at any fixed temperature to obtain a definite degree of dimensional stabilization is significantly less for the cross-linking reaction than for the straight heat-stabilizing reaction. This is brought out more forcibly by crease tension tests. Figure 10 gives the dry tensile strength in the machine direction of both creased and uncreased specimens. Creasing reduces the tensile strength of the formaldehyde cross-linked paper significantly only when the paper has relatively greater reduction in swelling. On the other hand, creasing reduced the tensile strength of heat-stabilized paper with any degree of reduction in swelling. In papers with large reductions in swelling, tensile strength was reduced practically to zero by creasing. In cases where the treatment greatly embrittled the paper, concentration of stresses occurs at the crease, and invariably the paper breaks there, too. In papers only slightly embrittled by the treatment, the break occurred only occasionally at the crease.

CONCLUSIONS

Dimensional stability is imparted to paper both by heat stabilization and by formaldehyde cross-linking reaction. The heat treatment has a heat of activation of about 28,000 cal. per mole irrespective of the presence of catalysts. If the paper has a zinc chloride content of 1.25%, however, the rate of the reaction is 46 times faster than the uncatalyzed reaction.

Formaldehyde cross-linking, which takes place only in the presence of a catalyst, has an activation energy of about 19,000 cal. per mole (13,000 cal. per mole when corrected to a constant concentration). The rate of the reaction is affected by the nature and amount of the catalyst present and the availability of the formaldehyde, but is not affected by the moisture content at which the reaction takes place, below 70% R.H. The reaction does not take place in the presence of free water. When formalin solution is used as the reactant, the reaction takes place only under drying conditions.

The dry strength properties of paper dimensionally stabilized by these methods seems to be reduced only as a result of embrittlement. The formaldehyde cross-linking reaction causes embrittlement and thus reduces tensile strength only at the higher levels of treatment. The heat stabilization reaction causes embrittlement and reduces tensile strength to some degree at moderate levels of treatment and to a high degree at the higher levels of treatment. Embrittlement has no effect upon ring compression strength.

The tensile strength of wet paper is greatly improved by both treatments, with some drop at the higher levels of treatment for heat stabilization. Large improvements in ring compression strength of wet paper occur at all levels of treatment. Strength values comparable to those obtained in wet paper by treatment with 6 to 10% of phenolformaldehyde resin can be obtained by heat stabilization with only a small amount of catalyst present and by cross-linking with as little as 0.5% of formaldehyde.

Both processes show promise as means of dimensionally stabilizing paper and giving it wet strength. Heat stabilization should be limited to applications where some embrittlement is permissible. Formaldehyde cross-linking should be more generally applicable because of the fact that it embrittles paper to a lesser degree.

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The Pulping of Mechanically Treated Wood

I. Crushed Softwoods

J. E. STONE and L. F. NICKERSON

Spruce and tamarack were crushed in three different ways —4000 p.s.i. parallel to the grain, and 4000 and 14,000 psi perpendicular to the grain. Together with uncrushed wood, the crushed spruce was pulped to about 59% yield in acid (pH 2.0) and neutral (pH 8.5) sulphite liquors. The crushed tamarack was pulped to about 50% yield in pH 2.0, 5.0, and 8.5 sulphite liquors, and by the kraft process. Chemical and physical properties were measured. Results showed that: (1) The rate of pulping and chemical composition of the pulps produced by any given liquor was unaffected by crushing; (2) crushing the wood parallel to the grain was much more detrimental to pulp quality than crushing perpendicular to the grain; (3) the greatest degradation of crushed wood occurred with the acid sulphite liquor, less with the bisulphite liquor, and least with the kraft and neutral sulphite liquors.

THERE is considerable evidence that subjecting wood to stress by some form of mechanical treatment, either before or during a cook, will tend to give an inferior pulp. The chipping of wood is a good example of an operating involving mechanical stress, and many workers have shown that machine-made chips give an inferior pulp to hand-made chips when cooked by the sulphite process (*1*, *4*, *5*, *9*, *18*, *24*). The effect is felt to be due to the wood being crushed by the chipper knife followed by a chemical attack on the damaged cell wall by the acid sulphite cooking liquor. Green and Yorston (*4*, *5*) studied this effect at some length and concluded the following: (1) machine-made chips are damaged more at one end than the other, shown by the fact that if the chips are sawed in half and pulped separately, one pulp is much stronger than the other, (2) crushing wood in the fiber direction results in greater fiber degradation than when crushing is carried out in a direction perpendicular to the fiber, (3) tensile forces do not appear to lead to fiber degradation, (4) wood crushed in the fiber direction is degraded less by kraft than by sulphite pulping. Bildt found (*2*) that a hammer blow on the end grain of wood was as effective as a slowly applied compressive load in degrading the fibers, and also found that the chipping of hot wood caused more damage than when the wood was cold. This latter effect has also been reported by Hagglund (*9*).

If wood has been disintegrated to fibers or sawdust before pulping, it would be expected to give poor sulphite pulps since a considerable amount of distortion, buckling, and compression of the cell wall must have been involved in the fiberizing. This was found to be the case by Jayme and co-workers in a series of studies on the pulping of Asplund fiber (*11–14*). Results indicated that a sulphite cook of asplund fiber gave a worthless papermaking pulp but might give a useful dissolving pulp if a high cooking temperature was used in order to reduce the reaction time. Kraft cooks (*13*) of Asplund fiber showed much more promise for papermaking pulps however, as did the use of chlorination and caustic extraction for delignification (*14*). This work was reviewed by Grogaard (*6*, *7*) who theorized that the reason why wood subjected to mechanical stress is degraded by cooking liquor is that the lignin in the cell wall protects the cellulose, the protective action being lost when the lignin sheath is cracked as the result of pressure. Grondal (*8*) presented a more detailed picture of the degradative processes, postulating the formation of faults or cracks in the cell wall which lead to a rapid penetration of cooking liquor and the development of shear planes during cooking.

The recent extensive work of Nolan and co-workers (*19*) on the kraft pulping of softwoods and hardwoods which have been preshredded by passing through a hammermill seems to indicate that quite severely damaged wood will produce a useful pulp if cooked under the right conditions.

McGovern and Simmonds (*17*) used a neutral sulphite liquor on chips of mixed hardwoods which had been passed between rollers 0.04 in. apart, causing severe crushing, and found that after bleaching there was no difference in burst, tear, and tensile strengths compared with uncrushed wood. No explanation was given for the lack of degradation, but presumably it could been have due either to the use of a neutral pulping liquor or to the mode of crushing (essentially perpendicular to the fiber axis). Runkel (*20*) states that NSSC pulps made from spruce sawdust may have acceptable physical properties, the breaking length sometimes exceeding 6000 m., but given no other figures. His view is that "the physical state of sawdust changes its behavior toward chemical attack and makes it extremely sensitive, but its morphological state by no means implies a destruction making the pulp unfit for papermaking use."

Levitin and Schwartz (*16*) produced pulps from spruce, poplar, and yellow birch sawdust using chlorine dioxide for delignification. The pulps were compared with bleached pulps, both kraft and sulphite, from regular spruce chips, and appeared to have some excellent characteristics. For example, at 300 C.S. freeness, two of the spruce sawdust pulps had a higher burst than, and equal tear to, the sulphite pulp from normal chips. The undegrading action of chlorine dioxide may be compared with the similar effect observed by Jayme and Wettstein (*14*) using chlorination.

The experience of commercial operators seems conflicting. Goodwin (*3*) has reported on kraft and neutral sulphite installations of the Pandia equipment in various parts of the world using both hardwoods and

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softwoods (chips or sawdust) and produced a variety of paper grades. The Pandia process involves a severe crushing of the chips in the continuous screw feeder, but is used for both unbleached and bleachable grades of pulp, which seems to suggest that mechanical degradation is not necessarily a prelude to poor quality. Kamyr on the other hand reports (*15*) that extensive trials with chip feeders of the plunger or screw type provided good evidence that the damage incurred by the wood under these conditions led to very poor pulp. As an example, as a result of the screw feeder, the double fold of a sulphite pulp was reduced from 3425 to 2. The kraft process was not quite as damaging to the quality of pulp from crushed wood, but the degradation was still very considerable, e.g., double fold reduced from 5500 to 125. Other strength properties were also affected adversely by the crushing, but the effect is demonstrated most dramatically by the change in double fold.

It is not only mechanical action on the wood before cooking which has a detrimental effect, but also mechanical action during the cook. Hagglund (*10*) reported that rotary digesters give a poorer sulphite pulp than stationary digesters for this reason. Samuelson and Wennerblom (*21*) studied the pulping of spruce chips by the sulphite process, some of the chips being fiberized part way through the cook and the cook then continued. The rest of the chips were left undisturbed throughout the cook. It was found that the disintegrated semicooked chips pulped faster than the unfiberized chips and gave a lower viscosity pulp in the same cooking time. When compared at the same viscosity (different cooking times) the lignin, pentosan, and yield from the disintegrated wood were slightly higher. After bleaching, the yields were about the same for the same viscosity. Recently Wacek, *et al.* (*23*), studied the effect of mechanical treatment during the sulphite pulping of spruce, using a "beater-autoclave" to permit the fiberizing to be carried out at any stage of the cook. The viscosity of the cellulose was determined by the nitration method and it was found that beating during the cook resulted in cellulose with much lower degrees of polymerization. Moreover, pulps from mechanically treated wood seemed to have a higher lignin content and lower carbohydrate than equal yield pulps from normal wood. No strength tests were made on the pulps produced by Wacek, *et al.*, or Samuelson and Wennerblom, their chief interest being dissolving pulp.

The foregoing discussion of previous work in this field, conflicting though it may be in some cases, shows that mechanical treatment of wood prior to cooking is liable to result in pulp with inferior strength properties. Questions which remain unanswered, or only partially answered because of the qualitative nature of the studies made, are as follows: (a) What is the relationship between pulp quality and the type of cooking liquor used, following a given mechanical treatment of the wood? (b) How does the relationship (a) vary with the severity of mechanical pretreatment?

In order to study the first question, it was decided to vary the nature of the cooking liquor over a wide range using sulphite liquor of pH 2.0, 5.0 and 8.5. Presumably the same type of pulping reaction is involved with each of these liquors, namely, a sulphonation of the

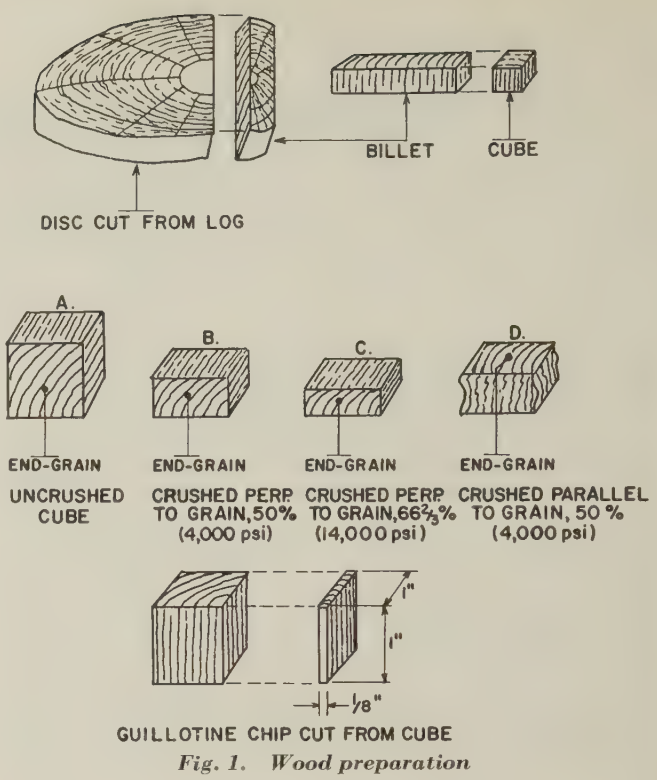

Fig. 1. Wood preparation

lignin, but hydrolysis reactions should differ markedly with such a difference in hydrogen ion concentration. A kraft cook was included in the case of one of the wood species used.

The mechanical treatment chosen was a severe crushing, either parallel or perpendicular, to the fiber axis. This method has the advantage of being fairly reproducible, of introducing known forces (on the macro scale) into the wood, of being directional, and of acting on all the fibers in a given specimen of wood. Moreover, the evidence obtained by Yorston (loc. cit.) that compression parallel to the fiber axis is more harmful than a compression at right angles to the fibers, seemed to need confirmation through quantitative experiments.

EXPERIMENTAL PROCEDURE

White spruce and tamarack (*Larix laricina*) were used for this investigation. One-inch cubes were prepared from the spruce by making, successively, disks, billets, and cubes. These three forms are shown in Fig. 1. The cubes were crushed individually in a hand-operated press while being held in a die. The tamarack was crushed in billet form in a 200-ton testing machine, five billets being crushed simultaneously which necessitated up to 175 tons total load on the 25 sq. in. of wood. The next operation was that of making $^1/_8$-in. thick chips from the crushed and uncrushed billets or cubes by splitting parallel to the grain in a guillotine chipper. The control pulps from uncrushed wood should therefore be considered as being made from the equivalent of handmade chips.

Table I. Crushing Conditions

Designation	*Crushing Direction*	*P.s.i.*	*Reduction in thickness, %*
A	Uncrushed (control)	...	...
B	Perpendicular to fiber axis	4,000	50
C	Perpendicular to fiber axis	14,000	$66^2/_3$
D	Parallel to fiber axis	4,000	50

Table II. Cooking Conditions

Sulphite, Bisulphite, and Neutral Sulphite Cooks

Cook no.	Wood species	Cooking cycle: Temp., °C.	Cooking cycle: Time to, hr.	Cooking cycle: Time at, hr.	Liquor/wood ratio	Original liquor: Total SO_2, %	Original liquor: Comb. SO_2, %	Original liquor: pH	Liquor/pH after impreg.	Blow liquor: Total SO_2, %	Blow liquor: Comb. SO_2, %	Blow liquor: pH	Sulphur consumption, g./100 G. pulp	Yield,[a] %
1075	T[b]	150	$1^1/_2$	$2^1/_4$	9:1	4.32	1.50	2.00	2.05	2.72	0.84	1.80	15.2	49.0
1064	T	165	$1^5/_{16}$	$3^1/_4$	9:1	2.98	1.50	5.02	5.00	1.46	0.72	3.35	13.2	52.0
1071	T	180	$2^1/_{16}$	$5^3/_4$	9:1	3.29	..	8.35	8.35	1.50	..	8.40	16.1	51.1
1050	S	150	$1^1/_2$	$1^1/_3$	10:1	4.28	1.52	1.98	2.10	2.98	1.02	2.05	11.5	60.1
1011	S	180	1	$4^1/_2$	10:1	3.43	..	8.50	8.50	1.88	..	8.20	13.5	58.7

Kraft Cook

Cook no.	Wood species	Cooking Cycle: Temp., °C.	Cooking Cycle: Time to, hr.	Cooking Cycle: Time at, hr.	Liquor/wood ratio	Original Liquor: Active alkali, g.p.l.	Original Liquor: Effective alkali, g.p.l.	Original Liquor: Sulphides, g.p.l.	Original Liquor: Sulphidity, %	Blow Liquor: Effective alkali, g.p.l.	Blow Liquor: Sulphides, g.p.l.	Yield, %
1078	T	170	$1^1/_2$	$1^1/_2$	9:1	22.3	18.9	6.75	30.0	7.3	4.8	49.9

[a] Uncrushed wood. Yields of crushed wood shown in Tables III and IV.
[b] T = Tamarack; S = Spruce.

The reason for holding the wood in a die during the crushing operation was to ensure that all the fibers in the block were involved in compression. Without the die, the blocks usually split into several pieces which moved sideways and escaped the full force of the compression load.

Table I shows the directions and pressures of crushing with the resulting reductions in thickness while under pressure; when the pressure was released, the wood always regained most of its original thickness. The moisture content of the uncrushed wood was in the range 34 to 37%, while that of the crushed wood was several percentages lower due to water being removed during the crushing operation.

The sulphite liquors of pH 2 and 5 were prepared from commercial grade sodium hydroxide and sulphur dioxide and contained 1.5% "Palmrose combined" SO_2. The liquor of pH 8.5 (neutral sulphite) was made from commercial grade chemicals and contained approximately 65 g.p.l. Na_2SO_3 and 16.5 g.p.l. $NaHCO_3$. Commercial grade sodium hydroxide and sodium sulphide were used for the kraft liquor (see Table II).

All pulping was carried out in a stationary 2-cu. ft. stainless steel digester. In order to obtain identical cooking conditions at each yield level for the crushed and uncrushed wood, a stainless steel wire-mesh basket was divided vertically into quarters, and contained representative 1-kg. charges of the uncrushed and three types of crushed wood.

To ensure penetration of cooking liquor into the chips, the digester was evacuated to approximately 2 cm. Hg absolute for 30 min. Following this, the digester was filled with liquor to a level well above the chips without allowing air to enter the system. The chips were impregnated with liquor at 25°C. for 1 hr. by applying 150 p.s.i. nitrogen pressure; at no time during this period did nitrogen come in contact with the wood. The nitrogen pressure was released, several liters of liquor were removed to give the desired liquor-to-wood ratio, and the temperature of the digester was raised to 80°C. within several minutes, after which a slower and linear rise was followed to the cooking temperature. In the sulphite and neutral sulphite cooks three different temperatures were used, depend-

Table III. Chemical Analysis of Pulps

Cook no.	Wood species	pH of cooking liquor	Total yield	Kappa no.	Cl_2 no.	Lignin: On pulp	Lignin: Residual	Alpha-cellulose: On pulp	Alpha-cellulose: Residual	Pentosans (uncorr.): On pulp	Pentosans (uncorr.): Residual	Sulphur content of pulp	C.E.D. viscosity cp.
Original wood		...	100.0	..	30.0	..	26.0	..	46.4	...	9.0		
1075A[a]	Tamarack	2.0	49.0	46.8	9.3	6.4	3.1	84.2	41.2	5.5	2.7	0.46	78.9
(1075)B		2.0	48.8	43.0	8.5	6.0	2.9	83.9	40.9	5.4	2.6		
C		2.0	49.0	42.3	8.4	5.7	2.8	83.8	41.0	5.7	2.8		
D		2.0	47.1	37.4	7.5	5.2	2.5	83.7	39.3	5.6	2.6		13.7
1064A	Tamarack	5.0	52.0	55.2	10.7	7.3	3.8	81.9	42.5	5.7	3.0	0.44	39.6
B		5.0	51.9	53.2	10.3	7.1	3.7	81.9	42.5	5.1	2.6		
C		5.0	53.3	51.9	10.6	6.9	3.7	81.7	43.5	4.9	2.6		
D		5.0	51.6	49.7	9.7	6.5	3.4	81.5	42.1	5.4	2.8		12.2
1071A	Tamarack	8.5	51.1	74.5	13.2	8.0	4.1	81.9	41.8	7.7	3.9	0.50	11.5
B		8.5	50.6	71.6	13.2	8.1	4.1	80.8	40.9	7.8	4.0		
C		8.5	50.7	68.8	12.7	7.7	3.9	81.1	41.1	7.7	3.9		
D		8.5	49.8	68.8	12.4	7.5	3.7	81.3	40.5	7.6	3.8		8.3
1078A	Tamarack	kraft	49.9	61.2	10.0	7.9	3.9	84.8	42.3	8.2	4.1	..	45.4
B		kraft	48.9	57.3	9.1	7.5	3.7	85.4	41.6	8.2	4.0		
C		kraft	49.5	56.5	9.0	7.3	3.6	85.7	42.5	8.2	4.1		
D		kraft	47.8	53.8	8.7	7.0	3.4	86.4	41.2	7.9	3.8		
Original wood			100.0	...	34.6	..	26.8	..	46.6	...	9.1		42.1
1050A	Spruce	2.0	60.1	86.1	16.9	12.5	7.5	76.5	46.0	6.5	3.9	0.64	76.3
B		2.0	59.1	83.3	16.1	12.3	7.3	76.8	45.5	6.5	3.8		
C		2.0	58.8	81.7	15.9	12.2	7.2	76.5	45.0	6.6	3.9		
D		2.0	58.2	76.6	15.3	11.7	6.8	76.4	44.5	6.6	3.8		13.5
1011A		8.5	58.7	96.5	17.6	11.7	6.9	77.9	45.6	8.2	4.8	0.68	13.1
B		8.5	59.8	95.5	17.4	11.6	6.9	77.3	46.2	8.3	5.0		
C		8.5	59.5	94.2	17.1	11.8	7.0	77.6	46.2	9.1	5.4		
D		8.5	58.1	93.3	16.7	11.7	6.8	77.7	45.1	8.0	4.7		8.9

[a] A. Uncrushed wood. B. Crushed 50% perpendicular to fiber axis (4000 p.s.i.). C. Crushed 66% perpendicular to fiber axis (14,000 p.s.i.). D. Crushed 50% parallel to fiber axis (4000 p.s.i.).

Table IV. Physical Properties of Pulps

Cook no.	Wood species	pH of cooking liquor	Yield, %	Beating time, min., freeness 500	Beating time, min., freeness 300	Bulk, cc/g., freeness 500	Bulk, cc/g., freeness 300	Burst factor freeness 500	Burst factor freeness 300	Tear factor freeness 500	Tear factor freeness 300	Breaking length, m., freeness 500	Breaking length, m., freeness 300	Stretch, %, freeness 500	Stretch, %, freeness 300	Double fold freeness 500	Double fold freeness 300	G.E. brightness
1075A	Tamarack	2.0	49.0	21	32	1.28	1.20	74	76	0.91	0.73	10,500	11,000	3.1	3.2	1360	1660	39.9
B		2.0	48.8	15	22	1.30	1.16	54	58	0.54	0.48	8,700	9,400	2.6	2.6	820	1820	41.7
C		2.0	49.0	15	23	1.27	1.19	53	56	0.53	0.50	9,100	9,300	2.3	2.5	600	800	43.3
D		2.0	47.1	7	13	1.27	1.18	19	19	0.195	0.17	4,600	5,100	1.1	1.2	4	6	40.5
1064A		5.0	52.0	26	37	1.33	1.27	78	79	0.86	0.73	12,400	12,600	2.6	2.6	1280	1450	41.2
B		5.0	51.9	18	25	1.34	1.22	58	61	0.62	0.52	10,400	11,250	2.5	2.6	700	830	45.4
C	Tamarack	5.0	53.3	18	26	1.35	1.24	57	60	0.57	0.50	10,700	11,300	1.6	1.7	520	730	40.3
D	Tamarack	5.0	51.6	10	15	1.33	1.22	29	31	0.28	0.24	6,900	7,700	1.2	1.2	20	30	43.3
1071A	Tamarack	8.5	51.1	32	42	1.44	1.34	90	96	0.86	0.76	13,200	14,200	2.8	2.8	940	1140	41.5
B	Tamarack	8.5	50.6	28	39	1.42	1.28	83	84	0.84	0.69	12,100	13,200	2.5	2.4	930	1240	42.8
C	Tamarack	8.5	50.7	30	41	1.40	1.33	80	84	0.75	0.65	12,400	12,800	2.2	2.2	870	1070	42.3
D	Tamarack	8.5	49.8	23	35	1.39	1.30	63	65	0.58	0.52	10,500	11,000	2.2	2.2	940	1220	43.8
1078A	Tamarack	Kraft	49.9	67	94	1.40	1.31	104	107	1.39	1.20	12,100	12,800	4.0	4.1	2120	2660	
B	Tamarack	Kraft	48.9	61	87	1.41	1.32	94	100	1.24	1.10	11,600	12,550	3.8	4.0	2200	3080	
C	Tamarack	Kraft	49.5	65	94	1.37	1.31	96	95	1.16	1.03	11,900	12,400	3.9	3.9	2200	3500	
D	Tamarack	Kraft	47.8	62	88	1.44	1.34	74	76	0.91	0.81	9,500	10,200	3.8	3.8	1990	2400	
1050A	Spruce	2.0	60.1	30	48	1.28	1.22	98	102	0.60	0.58	14,600	16,000	3.0	3.3	1370	1570	
B	Spruce	2.0	59.1	25	38	1.24	1.20	71	76	0.47	0.41	12,900	14,300	2.6	2.9	1200	1200	
C	Spruce	2.0	58.8	22	35	1.26	1.19	71	71	0.45	0.42	12,700	12,900	2.3	2.3	930	1060	
D	Spruce	2.0	58.2	10	17	1.26	1.17	25	27	0.17	0.15	6,300	7,000	1.2	1.4	3	4	
1011A	Spruce	8.5	58.7	54	73	1.34	1.28	112	107	0.60	0.55	15,800	15,700	3.2	3.1	930	1020	
B	Spruce	8.5	59.8	52	70	1.34	1.30	103	103	0.58	0.54	15,000	15,600	3.0	3.0	900	1000	
C	Spruce	8.5	59.5	56	75	1.34	1.28	98	96	0.58	0.53	15,000	15,200	2.9	3.0	960	980	
D	Spruce	8.5	58.1	50	66	1.34	1.26	74	69	0.46	0.40	11,400	11,200	3.0	2.7	840	900	

ing upon the pH of the liquor. While this may invalidate a precise comparison between pulps produced with the various liquors, it nevertheless resulted in cooking cycles of reasonable length. At the end of each cook the liquor was removed, and brightness samples were taken from the pulp in each quarter of the basket in those cases where brightness determinations were later made. The digester was filled with cold water, both to wash and cool the pulp for easy handling.

After removing the pulp from the digester it was broken up in a Cowles dissolver using a 6-in. impeller, the time of such treatment in each case depending upon the yield. Semipulped chips and large fiber bundles were removed by screening through a 6-cut laboratory pulp screen.

Following the screening operation the yield was determined by the consistency method using a 620-l. tank. The brightness sample and screened reject weights were added to this screened yield. Handsheets were made for the required chemical tests, while the remainder of the pulp was used for physical evaluation.

Pulp Testing

The following chemical tests were used:

Roe chlorine number	PPRIC modification of TAPPI Standard T 202 m-45
Klason lignin	TAPPI Standard T 22 m-52
Kappa number	PPRIC modification (*22*) of TAPPI Standard T 214
Alpha-cellulose	TAPPI Standard T 203 m-44, using unbleached pulp and correcting for total lignin determined in the original sample
Pentosans	TAPPI Standard T 223 m-48. No correction for hexosan was made
CED viscosity (0.5%)	TAPPI Standard T 230 sm-50 except that bleaching was carried out in $NaClO_2$ for 24 hr. at 25°C. instead of 30 min. at 80°C.
Sulphur	Institute procedure CS 1, Leco combustion method
Physical tests:	
Beating	Valley beater
Freeness	Canadian Standard
Bulk	Cubic centimeters per gram
Burst factor	Metric units
Tensile	Breaking length, meters
Tear factor	Metric units
Double fold	M.I.T.

RESULTS

From Table II it can be seen that the pH of the cooking liquor had a very marked effect on the rate of pulping, as would be expected. The time required to pulp to a given yield differed so much that it was necessary to use different cooking temperatures with each liquor in order to complete each cook in a reasonable time. Thus, $2^1/_4$ hr. at 150°C. produced a 49% yield pulp with the pH 2.0 liquor, whereas $5^3/_4$ hr. was required with the pH 8.5 liquor, even though the temperature had been raised to 180°C. If a doubling in rate for each 10°C. rise is assumed, this implies that a liquor at pH 8.5 pulps about 20 times slower than a liquor at pH 2.0. The difference is even marked more in the case of the *ca.* 59% yield pulps from spruce, being about 27 times slower. It appears, therefore, that if for reasons of quality (to be discussed later) or some other reason it is desired to pulp softwoods with a neutral sulphite liquor, then either very long cooking times or high temperatures would be required. For rapid continuous digestion in neutral liquor, temperatures in excess of 200°C. seem indicated.

From Tables III and IV, it is seen that crushing the wood perpendicular to the fiber axis, even at 14,000 p.s.i., had no effect on the rate of pulping. Crushing parallel to the fiber axis had a small effect, the yield of pulp being 1 to 2 points lower than the yield from the other wood cooked in the same digester. This loss in yield is probably due to a loss of fines during the screening operation rather than to more rapid pulping or to the excessive dissolution of a single wood component. This is shown by the very similar chemical analyses on all the pulps.

Because the pulps produced by the several cooking liquors are not identical in yield it is difficult to make a strict comparison of their chemical compositions. An

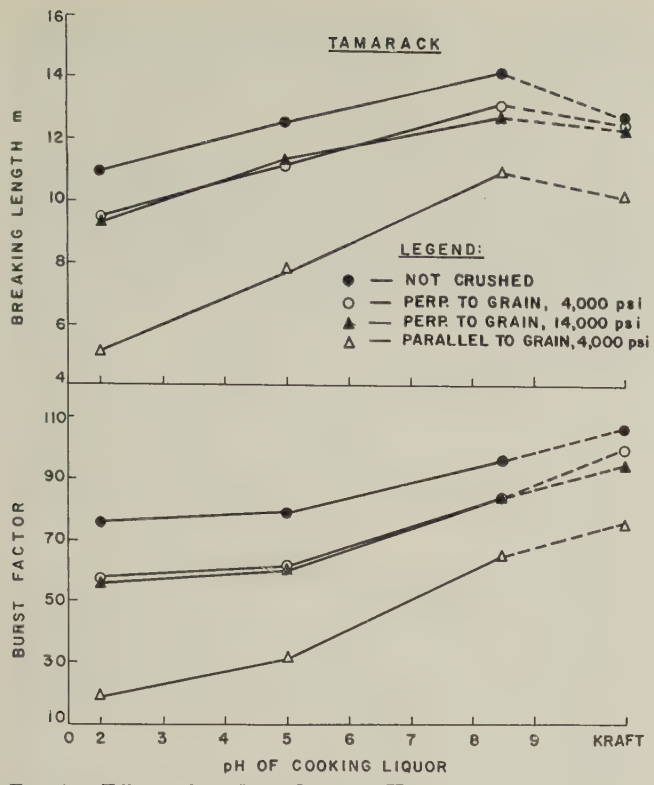

Fig. 2. Effect of cooking liquor pH and crushing on pulp quality

additional complicating factor is the different response of dissimilar pulps to the analytical methods used. For example, the two sets of spruce pulps—one produced at pH 2.0 and the other at pH 8.5—are identical in yield, and yet the pH 8.5 pulps apparently have a higher kappa number, chlorine number, pentosan, and alpha-cellulose content (Table III). If these determinations represented (or were proportional to) the true lignin, hemicellulose and alpha-cellulose contents of the pulps, such a result would, of course, be impossible. This leads to the conclusion that a strict comparison of the composition of dissimilar pulps is unwarranted with the analytical methods used in this work. When the slight difference in yield is allowed for, Table III shows that the type of cooking liquor used—acid, neutral or alkaline—had only a slight effect on the composition of the pulps. The chief difference occurs in the pentosan value, the pentosan content of the neutral and alkaline pulps being significantly higher than that of the acid sulphite and bisulphite pulps.

Table III also reveals that crushing the wood before cooking had no effect on the chemical composition of the pulps.

Results are given in Table IV and shown graphically in Figs. 2–5. From an examination of these figures it is immediately apparent that, in contrast to the small effect on chemical composition, crushing the wood and cooking in different liquors has a very marked effect on the physical characteristics of the pulps. Considering first the effect produced by changing the cooking liquor, using wood that had not been crushed, it is seen from Figs. 2 and 3 that the kraft pulp is the strongest in tear, fold, and burst, and the neutral sulphite is strongest in tensile. The neutral sulphite pulp is equal in tear, superior in tensile and burst, and inferior in double fold to the acid sulphite pulp. From Fig. 4 it is seen that the beating time to 300 ml. C.S.F. increases with increasing alkalinity of the cooking liquor up to pH 8.5 and then more than doubles for the kraft pulp. The density of the sheet produced under standard conditions decreases with increasing pH, and this difference in density should be allowed for when comparing the strength properties of the pulps. Thus, the superiority of the neutral sulphite pulp over the acid sulphite pulp in burst and tensile would have been even more marked if the wet handsheets had been pressed to the same densities.

The difference between the several cooking liquors shows up most strongly in their effect on the crushed wood. The strength properties are reduced to the greatest extent in the liquor of pH 2.0, somewhat less at pH 5.0, and least in the pH 8.5 and kraft liquors. Crushing the wood parallel to the fiber axis resulted in the greatest lowering of pulp quality. Crushing perpendicular to the fiber axis was much less harmful, and it apparently made little difference whether the wood was crushed to one-half its original thickness using 4000 p.s.i. or one-third its original thickness using 14,000 p.s.i. The effect of crushing is best seen by an examination of the graphs, but a few outstanding effects are worth mentioning. The double fold test seems particularly sensitive to crushing and pH, the value being reduced virtually to zero by crushing parallel to the grain and cooking in pH 2.0 liquor, whereas the pH 8.5 liquor had no degrading effect on similarly crushed wood so far as this test is concerned. This is true of the tamarack pulps at ca. 50% yield and the spruce pulps at ca. 59% yield. The kraft and neutral sulphite liquors behave quite similarly toward crushed woods; the actual strength values obtained from the crushed-wood pulps may vary from kraft to neutral sulphite, but the percentage reduction in strength from

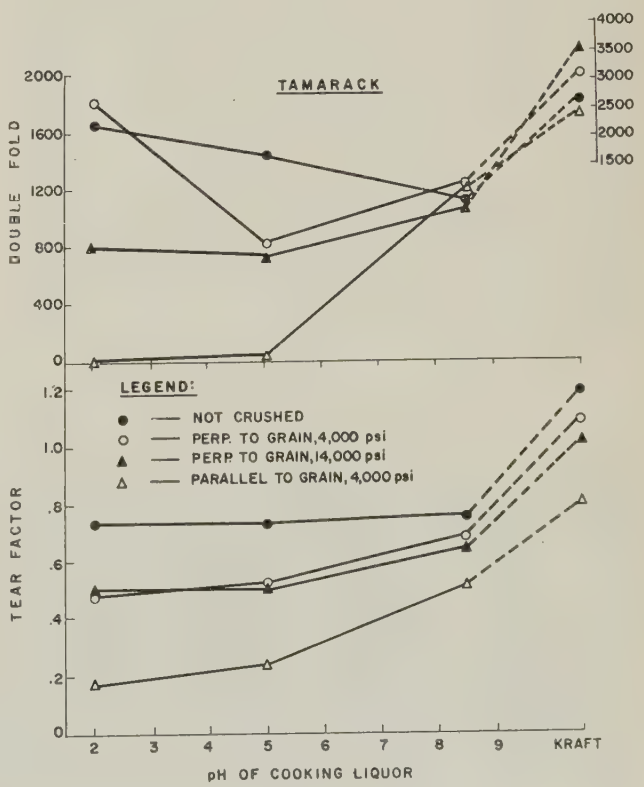

Fig. 3. Effect of cooking liquor pH and crushing on pulp quality

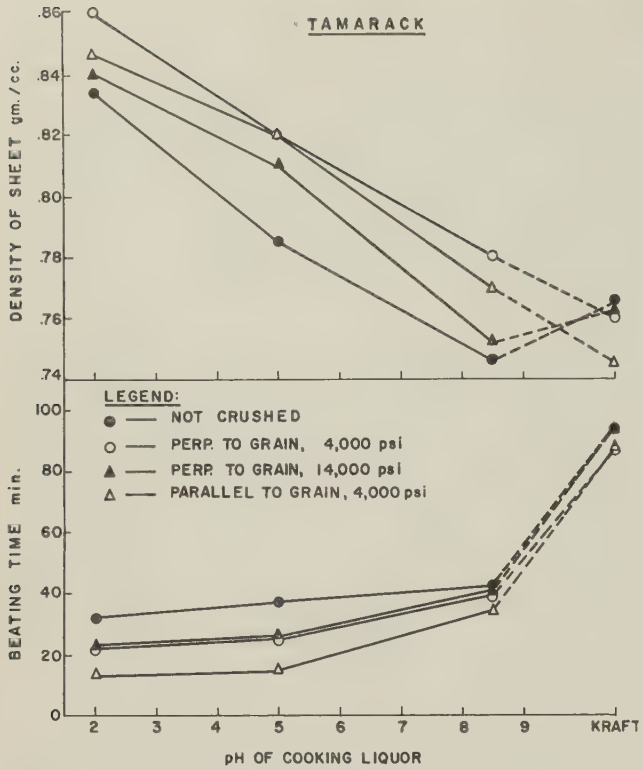

Fig. 4. Effect of cooking liquor and crushing on pulp quality

the control values (uncrushed wood) is the same in both cases. Thus, wood crushed parallel to the grain results in a kraft pulp of 67% normal tear and neutral sulphite pulp of 68% normal tear. The burst is reduced to 71% for kraft and 68% for neutral sulphite. The tensile strength is reduced to 80% for kraft and 78% for neutral sulphite. By contrast, the pH 5.0 and 2.0 cooking liquors very sharply reduce the strength properties of pulp from crushed wood. Thus, the pH 2.0 liquor gives a pulp with a burst of 25%, tensile of 46%, tear of 23%, and fold of less than 1% of normal.

The percentage reduction in strength which occurs when spruce is crushed parallel to the fiber axis and cooked in either a pH 2.0 or pH 8.5 liquor is shown in Fig. 5. The difference between the two liquors is immediately apparent. Whereas the pH 2.0 liquor reduced the quality of pulp from crushed wood to the point where it is virtually useless for papermaking purposes, the pH 8.5 liquor is apparently capable of preserving a worth-while percentage of the normal pulp strength. This is particularly true of the folding endurance; the pH 2.0 liquor reduces the value to zero whereas the pH 8.5 liquor preserves 88% of the "uncrushed" fold. The same figure (Fig. 5) shows that crushing spruce perpendicular to the fiber axis and cooking in a neutral liquor results in essentially no loss of strength. The pH 2.0 liquor resulted in a loss of about 25% of the uncrushed strength.

DISCUSSION

The results show the wood which has been crushed perpendicular to the fiber axis leads to acid sulphite pulps which have somewhat lower strength than normal but still retain sufficient strength to be useful in many applications. Neutral sulphite and kraft liquors cause very little degradation of pulps from wood crushed in this way.

Wood which has been crushed parallel to the fiber axis gives a useless papermaking pulp by the acid sulphite process. A liquor pH 5.0 offers some protection but the pulp is still very poor. Neutral sulphite and kraft on the other hand are capable of preserving much of the intrinsic strength of the pulps when longitudinally crushed wood is used.

Most mechanical treatments of wood, including chipping, will involve stresses with a component parallel to the fiber axis. It appears likely therefore, that under practical conditions there is a much greater chance for an acid sulphite cook to turn out poorly than would be the case for neutral sulphite or kraft. In other words, the acid sulphite process is very sensitive to wood handling methods whereas the neutral and alkaline processes are rather insensitive. For maximum strength, however, even the nonacid processes require wood which has been handled with some degree of care. It seems unlikely that chip feeders of the screw type, which compress the chips into a plug, will give pulps with equal strength to those from uncompressed chips. This statement should be qualified somewhat. Pulps for corrugating medium require special properties which are not measured by the tests made in this study. Crushing therefore may decrease tensile, tear, burst, etc., but not diminish the qualities important for corrugating medium. The same argument applies to other specialties. It must also be pointed out that the present work was on softwoods and it is not known how hardwoods would respond to a crushing operation.

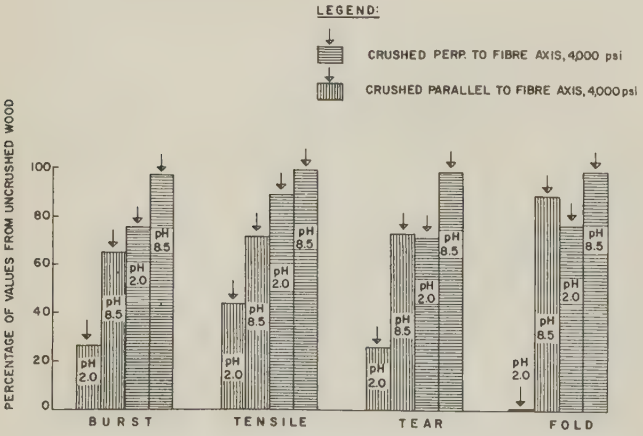

Fig. 5. Effect of cooking liquor pH and crushing on pulp quality white spruce

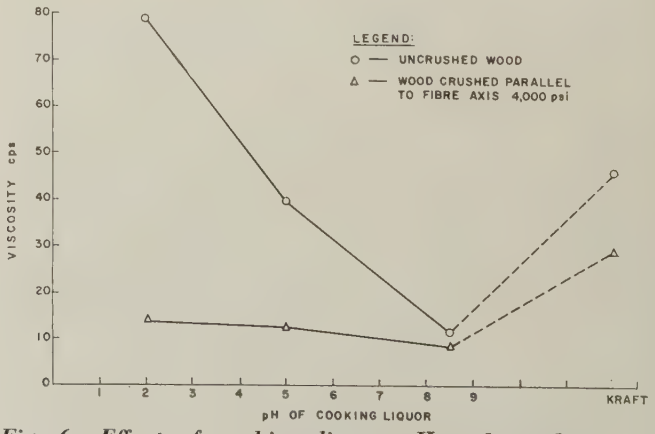

Fig. 6. Effect of cooking liquor pH and crushing on viscosity

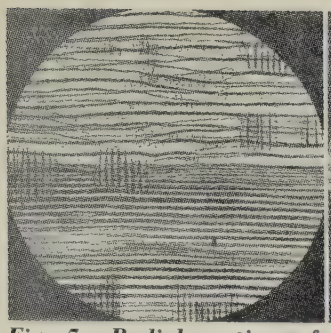

Fig. 7. Radial section of tamarack. Uncrushed

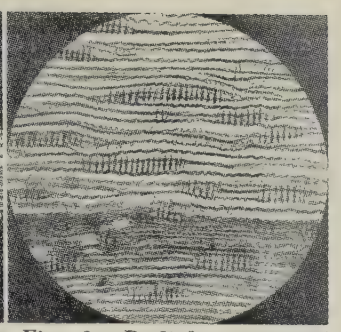

Fig. 8. Radial section of tamarack. Crushed parallel to fiber axis

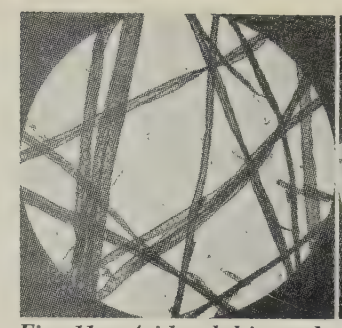

Fig. 11. Acid sulphite pulp from uncrushed wood (1075A) unbeaten

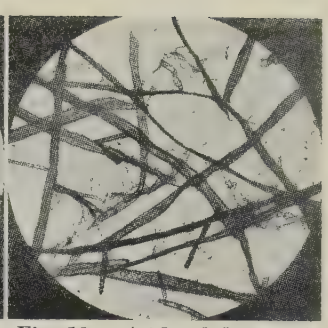

Fig. 12. Acid sulphite pulp from uncrushed wood (1075A) beaten to ca. 300 ml. C.S.F.

This will be studied later. Another unknown is the exact relationship between the crushing carried out here and that which occurs under practical conditions or under some other conditions. For example, steaming the chips before crushing, crushing hot rather than cold chips, dry rather than wet chips, or the use of pressures other than 4000 p.s.i. would all no doubt affect the results obtained. The fact remains, however, that under similar conditions of crushing, neutral and alkaline pulping liquors are markedly less destructive toward the pulp than is an acid liquor. No ready explanation for this will be forthcoming from the present study but will be a major objective of future work.

In seeking an explanation for the different effect of acid and nonacid liquors, very little help is given by the chemical analyses. The analyses made are much too similar for the acid, neutral, and alkaline pulps, crushed and uncrushed, to explain the large differences in physical properties. Particularly difficult to understand is how a neutral liquor, which involves the same type of delignification reaction as an acid liquor and has removed approximately the same wood components in the same ratio, has nevertheless been less vigorous in attacking the zones of weakness introduced by the crushing. Possibly a determination of mannan or other polysaccharides would have been more meaningful than the pentosan determination, and might have provided a chemical clue to the reasons for the physical differences.

The specific viscosity of the pulps from the uncrushed and most severely crushed (parallel to grain) wood was determined in cupriethylene diamine and the values obtained are shown in Fig. 6. A most unexpected result was the apparent dependence of viscosity on the pH of the cooking liquor when comparing the pulps from the uncrushed wood. The highest viscosity (78.9 cp.) was obtained from the acid sulphite pulp; this dropped to 39.6 cp. for the bisulphite pulp, dropped still further to 11.5 cp. for the neutral sulphite pulp, and rose again to 45.4 cp. in the case of the draft pulp. No explanation can be given for this behavior. The alpha-cellulose contents of the pulps are quite similar, the strength properties of the pH 8.5 pulp are at least as high and usually higher than that of the pH 2.0 pulp, and the much smaller degradation of the fiber which occurs when the pH 8.5 liquor is used on crushed wood suggests a smaller likelihood of breaking cellulose chains. Nevertheless, the 0.5% C.E.D. viscosity of the pH 8.5 pulp is only a fraction of that obtained from the pH 2.0 pulp. It seems that either (1) the sodium chlorite used for bleaching, or (2) the cupriethylenediamine used for the viscosity measurement degrades the pH 8.5 cellulose more than the pH 2.0 cellulose. Alternatively, the viscosity as measured bears no relationship to the actual D.P. of the celluloses.

Crushing the wood resulted in lower viscosities regardless of cooking liquor used. The greatest drop occurred with the pH 2.0 liquor as might have been expected. The highest viscosity after crushing was obtained using kraft liquor. This is also not unexpected when the strength properties of the kraft pulp from crushed wood are considered. The low viscosity of the neutral sulphite pulp from crushed wood, however, cannot be explained until the reason for the low viscosity from uncrushed wood is determined.

In Figs. 7–10 are shown photomicrographs of sections cut from the crushed and uncrushed tamarack. By comparing Figs. 7 and 8 is seen that crushing parallel to the fiber axis causes severe distortion of the cell walls throughout the length of the fibers. Details of this distortion can be seen most readily in the springwood where the normally straight wall of the tracheids has been changed into a regularly undulating ropelike structure. The appearance of the wall suggests that during compression the central layer of the secondary

Fig. 9. Cross section of tamarack. Uncrushed

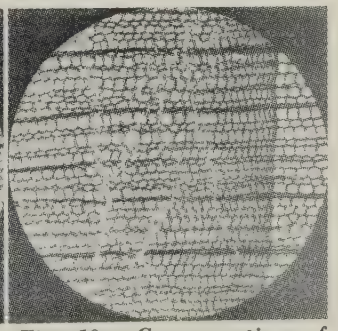

Fig. 10. Cross section of tamarack. Crushed perpendicular to fiber axis

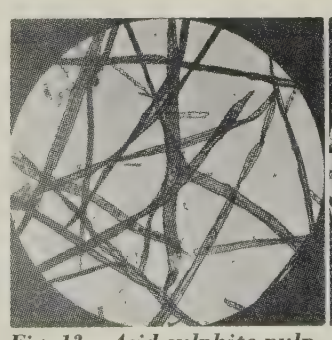

Fig. 13. Acid sulphite pulp from crushed wood (1075D) unbeaten

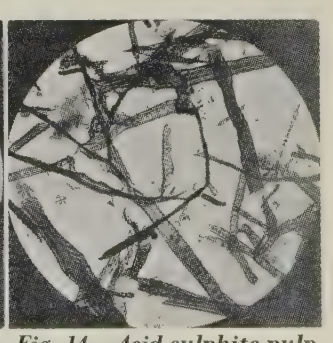

Fig. 14. Acid sulphite pulp from crushed wood (1075D) beaten to ca. 300 ml. C. S. F.

wall expanded due to the compression of the steeply pitched helix into a helix of lesser pitch and larger diameter. This expanding central layer broke through the outer layer at regular intervals, and when the compressive load was released and the cell walls attempted to resume their original shape, the spiralled appearance remained. Compression of the wood as preformed in the present study does not apparently produce local damage at a few points in the wall, but rather affects the whole wall in a uniform manner. At this point the fiber must still retain a considerable percentage of their original strength, as evidenced by the not inconsiderable strength of the kraft and neutral sulphite pulps which can be obtained from this wood.

Figure 10 shows wood which has been compressed perpendicular to the fiber axis to one-half its original thickness (4000 p.s.i.). A certain amount of fissuring has occurred with a number of tracheids sheared in half, but on the whole the cells exhibit a remarkable ability to withstand breakage or permanent deformation. The elastic nature of the deformation under a 50% strain appears somewhat incompatible with the theory of Jayme *et al.* (*11–14*) and Grogaard (*6*, *7*) that cellulose is embedded in a rigid matrix of lignin which is cracked by the application of mechanical stress.

In Figs. 11 to 14 are shows the pulps obtained from the acid sulphite cook (pH 2.0) of tamarack, crushed and uncrushed, and in the unbeaten and beaten (approx. 300 ml. C.S. freeness) states. Comparing Figs. 11 and 12 (uncrushed wood) the normal difference between unbeaten and beaten pulp is seen, the latter exhibiting considerable fibrillation with very little fiber shortening. Comparing Figs. 13 and 14, however, which relate to pulps from crushed wood, it is seen that although the unbeaten stock appears quite normal, the beaten stock contains a considerable amount of broken fibers with comparatively little fibrillation. Evidently the crushed-wood fibers break up in the beater before sufficient work can be done on them to produce fibrillation, a freeness of 300 ml. being reached in 13 min., due to the ease of producing fines. The uncrushed-wood fibers were able to take 32 min. beating before the 300 ml. freeness was reached, a sufficient time to produce good fibrillation.

From Fig. 13 it is seen that an acid sulphite cooking liquor does not reduce a severely crushed wood to "mush." To the unaided eye as well as microscopically it is very difficult to tell whether the pulp originated from normal or crushed wood. It is only after beating that differences start to show up and even then they are far from obvious. The unbeaten pulps shown in Figs. 11 and 13, although similar in appearance, are vastly different in strength properties. The differences which exist, therefore, are either at a submicroscopic level or require special staining or microscopic techniques to be revealed.

Since kraft and sulphite liquors behave so differently toward wood which has been under strain, it is interesting to speculate whether some of the differences which exist between kraft and sulphite pulps from "normal" wood are due in part to the stresses introduced into the wood during growth, e.g., through bending in the wind.

SUMMARY

1. Crushing wood parallel to the fiber axis is much more detrimental to pulp quality than crushing under considerably greater loads in a direction perpendicular to the fiber axis.

2. When wood has been crushed parallel to the fiber axis and cooked to similar yield in various pulping liquors, the greatest degradation of pulp quality occurs with the acid sulphite liquor of pH 20., somewhat less with a bisulphite liquor of pH 5.0, and least with neutral sulphite and kraft liquors.

3. Neutral sulphite and kraft liquors result in approximately equal degradation, but the kraft pulp from uncrushed wood is so superior in tear and double fold that the degradation which occurs as a result of crushing still leaves a useful pulp. Thus, the tear and double fold values of the kraft pulp from the most severely crushed wood were greater than the values obtained from uncrushed wood using any other liquor.

4. Crushing the wood has a negligible effect on the rate of pulping or the chemical composition of the pulps.

5. Crushing the wood parallel to the grain results in lower viscosities from the bleached pulps. The viscosity varies with the pH of the cooking liquor, but in an irregular manner.

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Determination of the Type of Damage in Papermaker's Felts

J. L. HANCHETTE and R. H. BEAUMONT

Burte's method for the detection of chemical modification in wool has been extended to conditions which commonly degrade papermaker's felts. These include solutions of alkali, chlorine, and enzymes. This method, which depends upon the ratio of fiber wet-state properties to dry-state properties, has been found useful for detecting each of these types of felt damage.

FELTS are removed from the paper machine when they are worn out, fail to give adequate drainage, or yield unsatisfactory finish. The rate at which they reach this condition can be influenced by a number of factors including: (1) mechanical, (2) chemical, or (3) bacterial degradation. For the papermaker to operate most economically and the feltmaker to engineer the best possible felt, it is necessary to know which of these factors are of significance. This can only be ascertained if methods are available for positively detecting these various types of degradation in a used felt.

Recent work in this laboratory (*2*) has shown that it is possible through chemical analysis to positively establish the presence of damage in felts which have been subjected to either alkaline or oxidative attack. Many other types of degradation, however, including that caused by acid, reducing agents and enzymes, do not yield readily isolated products for analysis. Consequently, there was a great need for a test with a broader spectrum.

The detection of chemical modification in wool based upon the measurement of the mechanical properties of single fibers has recently been reported by Burte (*1*). In this method it is assumed that chemical modification causes a much greater change in the wetstate physical properties of a fiber than in the dry-state properties. Consequently, a numerical ratio of the parameters of the fiber properties should give an indication of the extent of chemical degradation in the individual fibers. This method should be particularly useful for papermaker's felts as it can be assumed that purely mechanical degradation affects wet-state and dry-state properties equally.

To test the versatility of this method, it has been extended to various types of degradation which commonly occur in felts. For some of these it has been found to be a sensitive test method. Where significant change occurs in dry-state as well as in wet-state properties, as is often the case, however, it serves mainly as an indication and is most desirably supplemented by other tests.

EXPERIMENTAL

The stress-strain properties of single wool fibers were measured with an Instron tensile tester. Randomly selected fibers of New Zealand 44's fleece wool were mounted with Duco cement between cellulose acetate tabs placed 1 in. apart. Wet properties of the samples were determined by extending the fibers 10% in water buffered to a pH of 6.7. Dry properties were determined by extending the fibers to 10% after they had dried to equilibrium regain in a room maintained at 75°F. and a relative humidity of 65%. Properties were measured both before and after exposure to a variety of solutions.

Exposure conditions were essentially as described previously (*3*, *4*). Alkalinity was controlled with a combination of phosphate and borate buffers which were adjusted to the desired pH as measured with a high pH electrode. Stirred solutions of chlorine were buffered to a pH of 4.7. Chlorine concentrations were maintained within ±0.25 p.p.m. by periodic addition of sodium hypochlorite. Their concentration was checked colorimetrically with *o*-toluidine.

Bacterial degradation studies were made by exposing the fibers to a *Bacillus subtilus* culture at a pH of 6.0 and at 40°C. A modification of the Lennox (*5*) method

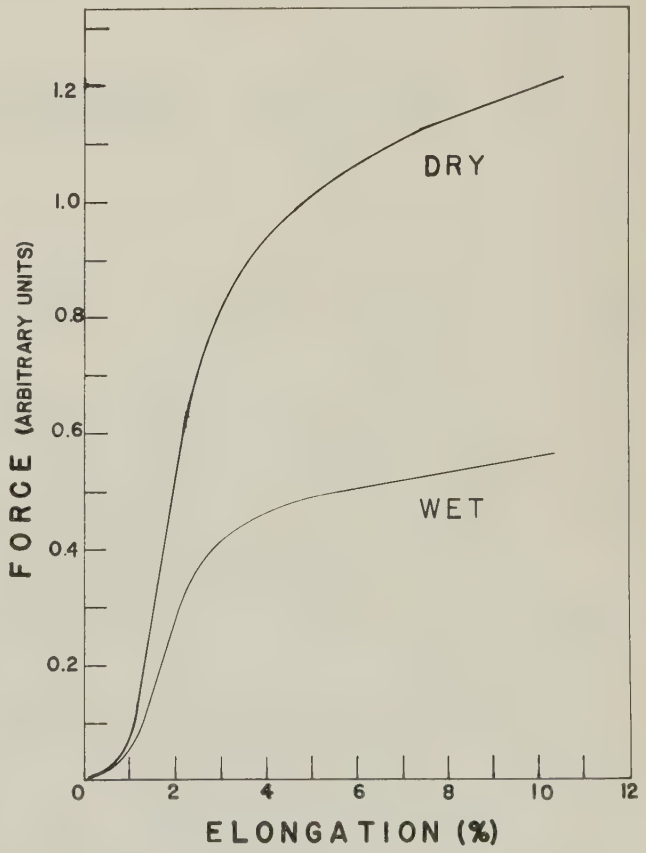

Fig. 1. Typical wool fiber stress-strain curves

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Table I. Effect of Alkaline Solutions on Wool
Time = 24 hrs: temperature = 75°F.

pH	(k_{wet}/k_{dry})	k_{wet} *Decrease, %*	*Lanthionine, %*
4.7	0.53 ± 0.08[a]	00.0	0
10.0	0.48 ± 0.06	11.5	0
11.0	0.46 ± 0.04	14.9	10
11.5	0.45 ± 0.05	21.2	20
12.3	0.15 ± 0.02	74.2	50

[a] 90% degree of confidence.

was used to degrade fibers under conditions simulating those which bacteria produce. The fibers were exposed to a solution containing 0.25% papain, 0.025 *M* sulphite, 0.75 *M* urea, and sufficient Na_2HPO_4 to adjust the pH to 6.9. An exposure time of 14 hr. at a temperature of 40°C. was used.

DISCUSSION

Typical stress-strain curves of a wool fiber in the dry-state and in the wet-state are shown in Fig. 1. In the lower portion of each of these curves the crimp is removed as the fiber is elongated. In that portion of the curve which follows, known as the Hooke's Law region, elongation is directly proportional to the force applied. The slopes of the curves in this region, k_{dry} and k_{wet}, are indicative of the properties of the fibers. The ratio of these slopes (k_{wet}/k_{dry}) has been found on the average to be constant in undamaged fibers regardless of fiber diameter. Fiber properties are not destroyed during testing provided they are not elongated more than approximately 10%.

In Fig. 2 the stress-strain curves of the same fiber after exposure to a solution of pH = 11.0 at room temperature for 24 hr. is compared with the original curves. It is seen that while the dry-state slope has changed

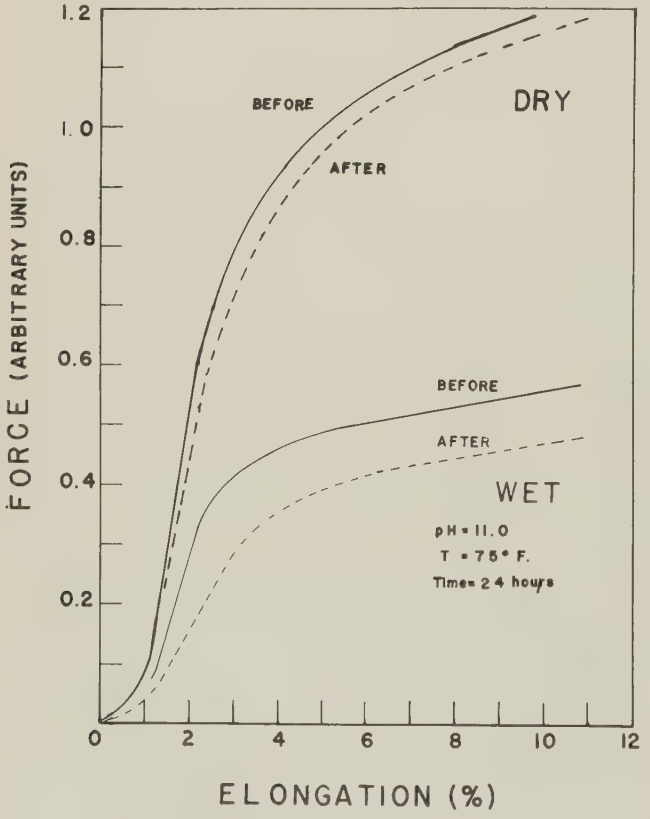

Fig. 2. Fiber stress-strain curves before and after alkaline degradation

Table II. Effect of Chlorine Solution on Wool Fibers
Time = 24 hrs: pH = 4.5: temperature = 75°F.

Chlorine, p.p.m.	k_{wet}/k_{dry}	k_{wet} *decrease, %*	*Cysteic acid, %*
0.0	0.49 ± 0.07	0.0	0
0.5	0.52 ± 0.06	7.0	5–10
2.0	0.49 ± 0.07	16.5	15–20
6.0	0.36 ± 0.05	58.4	50–60

little, a marked decrease has occurred in the wet-state slope with a consequent decrease in the ratio. The effect of alkali, chlorine, and enzyme-producing bacteria has been studied this way.

RESULTS

Alkali

To determine the sensitivity of the method for the detection of degradation resulting from alkaline solutions, fibers were exposed to various solutions of controlled pH for 24 hours at room temperature. The results of the subsequent tests are shown in Table I.

It is seen from the parameter (k_{wet}/k_{dry}) that while damage is questionable at pH = 10.0, it is significant at pH = 11.0 and above. This is in agreement with data obtained by comparing the stress-strain curves of fibers before and after exposure. Paper chromatographic tests for lanthionine confirm this result and somewhat more clearly indicate that no significant damage occurred at pH = 10.0. Thus, it can be concluded that the method is capable of detecting the presence of even low levels of alkaline damage.

Chlorine (Oxidation)

Similarly, wool fibers were exposed for 24 hr. under controlled conditions to solutions containing various concentrations of chlorine. The results of the subsequent tests are shown in Table II.

Here again a decrease in the ratio of slopes is noted. It is significant only after considerable degradation of the fibers has occurred, however. The reason for this is, of course, that while the wet-state properties of the fibers decreased significantly the dry-state properties decreased at a nearly equal rate. This is quite different from the results obtained upon exposure of fibers to alkaline conditions and it is very questionable if mild degradation could be detected by this method. The paper chromatographic method is in this case both much more sensitive and specific.

Bacteria or Mildew

Damage caused by bacteria is another type of chemical damage which should be detectable by this general method. In this case, the wool is actually degraded by enzymes secreted by various bacteria rather than by simpler chemicals such as alkali or chlorine. While the precise type of degradation which occurs is dependent

Table III. Effect of Mildew on Wool Fibers
pH 6.0: temperature 85°F.

Time, hr.	k_{wet}/k_{dry}	k_{wet} *decrease, %*
0	0.50 ± 0.05	0.0
24	0.54 ± 0.06	3.7
48	0.50 ± 0.05	13.4
72	0.58 ± 0.08	4.0
96	0.57 ± 0.04	−1.7

Table IV. Effect of Papain on Wool Under Reducing Conditions

pH 6.9: temperature = 40°C.: time 14 hrs.

	k_{wet}/k_{dry}	k_{wet} decrease, %	k_{dry} decrease, %
Undamaged	0.450	...	...
Damaged	0.571	10	30

upon particular bacteria involved, certain bacteria are typical of many.

In these studies wool fibers were exposed by varying periods to aqueous solutions in which *Bacillus subtilus* one of the more common bacteria was known to be active. Following this exposure the completely unexpected results shown in Table III were obtained. Rather than a decrease in the (k_{wet}/k_{dry}) value a significant increase was observed which further increased with time of exposure.

During exposure however many of the original fibers were lost due to the formation of colonies of bacteria and consequent excessive weakening of small sections of the fibers. In view of this, there was question as to the validity of the results so it was felt desirable to expose the fibers to a more homogenous solution.

Therefore, a solution of the enzyme papain, which is known to attack wool in the presences of simple reducing agents, was chosen to simulate the conditions which bacteria produce. The results obtained following 14 hr. exposure of the fibers to this solution are shown in Table IV. There is again a very significant increase in the value (k_{wet}/k_{dry}). This is, as previously observed, due almost entirely to the decrease in the slope of the dry-state curve as the slope of the wet-state curve remained essentially constant.

If these data can be further confirmed by examination of felts which are known to have been degraded through bacterial action, a most significant discovery will have been made. Previously available methods of detecting bacterial damage have been of questionable value for fabrics such as papermaker's felts which are also subject to mechanical degradation. This test method should be specific as enzymatic attack is the only type known to increase the ratio of the slopes.

SUMMARY

A broad spectrum method for the detection of chemical degradation of felts has been investigated. Its sensitivity has been found to vary considerably with the specific chemical system which has caused the loss of properties. Apparently, the test is less sensitive for degradation influences which completely break chemical bonds without forming new cross linkages, oxidation for example, than for influences like alkaline solutions which form new though less satisfactory bonds.

The method shows promise of becoming a specific test for bacterial degradation. That type of damage alone among those studied actually increases the ratio of the wet-state to the dry-state properties.

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Alkaline Hydrolysis of Representative Hardwoods. III

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The 75% *n*-propanol extracts of 46 representative hardwoods were submitted to alkaline hydrolysis with boiling 4% NaOH. After removal of the neutrals with ether, the alkaline solutions were acidified and extracted with ether to give phenolic and acidic materials. The concentrated ether extracts of these materials were chromatographed to determine qualitatively the nature of the hydrolysis products. Where found, vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, vanillic acid, syringic acid, ferulic acid, *p*-hydroxybenzoic acid, and *p*-coumaric acid were then determined quantitatively by the paper chromatographic and spectrophotometric procedure described previously. As in the cases of the alkaline hydrolyses of the woods themselves, all propanol extracts, upon alkaline hydrolysis yielded vanillin, syringaldehyde, vanillic acid, and syringic acid. The other four compounds were found individually only in certain woods. The occurrence of these compounds and their qualitative and quantitative relationships are discussed. In addition, the relation of these compounds to other wood components is discussed.

STUDIES of the alkaline hydrolysis of 46 representative hardwoods have been reported recently (*1*, *2*, 3). In these studies, quantitative data were recorded for vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, vanillic acid, syringic acid, ferulic acid, *p*-hydroxybenzoic acid, and *p*-coumaric acid. These same representative hardwoods were also extracted with 75% *n*-propanol, and the present paper reports similar quantitative data for the alkaline hydrolysis of these extracts. In addition, qualitative data are presented for the products of alkaline hydrolysis of these propanol extracts.

The propanol extracts of these woods were submitted to paper chromatography in butanol-aqueous ammonia and in butanol-pyridine-water developers, but all resulting chromatograms were streaked and very difficult to interpret. Except for the presence of *p*-hydroxybenzoic acid in extracts of woods of the *Salix* family, no individual compounds could be positively identified on these chromatograms. The extracts were hydrolyzed by boiling with 4% NaOH solution, and after removal of the neutrals with ether, the alkaline solutions were acidified and extracted with ether to give phenolic and acidic materials. The concentrated ether extracts of these phenolic and acidic materials were chromatographed to

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Table I. Chromatographic Data for Acids and Phenols Fraction in Butanol-2% Aqueous Ammonia Developer

	Butanol-2% aqueous ammonia R_f[a]												
	0.00	0.03	0.08[b]	0.10[c]	0.12[d]	0.14	0.16	0.27[e]	0.38[f]	0.44[g]	0.69	0.76	0.80	0.90
Salix nigra	X	..	X	X	C	X	..	X	X	X	..	..	X	..
Salix babylonica	..	..	X	X	A	X	X	X	X	X	..	X	X	X
Salix eriocephala	X	X	X	X	D	..	..	X	X	X[h]	..	..	X	..
Populus tremuloides	X	..	X	X	A	X	..	X	X	X[h]	..	..	X	..
Populus grandidentata	X	..	X	X	A	..	..	X	X	X	X	..	X	..
Populus tacamahaca	X	..	X	X	C	..	..	X	X	X	X	..	..	X
Populus deltoides	X	..	X	X	A	..	..	X	X	X	..	..	X	..
Populus trichocarpa	X	X	X	X	A	..	..	X	X	X	X	..	X	X
Populus alba	X	..	X	X	C	..	..	X	X	X	X	..	X	..
Populus nigra	X	..	X	X	C	..	..	X	X	X	..	..	X	..
Populus tremula	X	..	X	X	D	..	..	X	X	X[h]	X	..	X	..
Juglans cinerea	X	..	X	X	..	..	..	X	X	X	..	..	X	X
Carya ovata	X	..	X	X	B	..	..	X	X	X	..	..	X	X
Betula lutea	X	..	X	X	..	X	X	X	X	X	..	X	..	X
Betula papyrifera	X	..	X	X	..	..	..	X	X	X	..	X	X	..
Alnus rubra	X	..	X	X	E	..	..	X	X	X	..	..	X	..
Carpinus caroliniana	X	..	X	X	..	..	..	X	X	X	..	..	X	..
Fagus grandifolia	X	X	X	X	B	..	X	X	X	X	X	..	X	..
Castanea dentata	X	..	X	X	..	X	X	X	X	X	..	..	..	X
Quercus alba	X	..	X	X	B	..	..	X	X	X	..	..	X	X
Quercus lyrata	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus borealis	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus velutina	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus falcata	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus coccinea	X	..	X	X	..	X	X	X	X	X	X	..	..	X
Quercus marilandica	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus catesbaei	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus phellos	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Quercus nigra	X	..	X	X	B	..	..	X	X	X	..	..	X	X
Ulmus americana	..	..	X	X	B	X	..	X	X	X	..	..	X	..
Magnolia grandiflora	X	..	X	X	B	..	..	X	X	X	X	..	X	X
Magnolia virginiana	X	..	X	X	B	..	..	X	X	X	..	..	X	X
Magnolia fraseri	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Liriodendron tulipifera	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Liquidambar styraciflua	X	..	X	X	..	..	..	X	X	X	..	..	X	..
Platanus occidentalis	X	..	X	X	D	X	..	X	X	X	..	..	..	X
Acer saccharum	X	X	X	X	..	..	..	X	X	X	..	X	X	..
Acer rubrum	X	..	X	X	..	..	..	X	X	X	..	..	X	..
Acer saccharinum	X	..	X	X	..	..	..	X	X	X	..	..	X	..
Acer negundo	X	..	X	X	..	X	..	X	X	X	..	..	X	X
Tilia americana	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Tilia heterophylla	X	..	X	X	E	..	..	X	X	X[h]	..	..	X	X
Nyssa aquatica	X	..	X	X	B	..	..	X	X	X	..	..	X	..
Nyssa sylvatica	X	..	X	X	B	..	..	X	X	X	X	..	X	X
Fraxinus nigra	X	X	X	X	..	..	X	X	X	X	..	..	X	X
Catalpa speciosa	X	..	X	X	D	X	..	X	X	X	..	..	X	..

[a] R_f determined by means of bis-diazotized benzidine spray.
[b] Syringic acid.
[c] Vanillic acid.
[d] This spot may be *p*-hydroxybenzoic acid, ferulic acid, *p*-coumaric acid, or any combination of these acids. Actual qualitative composition was determined by paper chromatography in benzene-formic acid developer (*1*). A = *p*-hydroxybenzoic acid; B = ferulic acid; C = *p*-hydroxybenzoic acid + ferulic acid; D = *p*-hydroxybenzoic acid + ferulic acid + *p*-coumaric acid; and E = ferulic acid + *p*-coumaric acid.
[e] This spot is positive to 2,4-dinitrophenylhydrazine and Mäule reagents.
[f] Syringaldehyde.
[g] Vanillin.
[h] Also contains *p*-hydroxybenzaldehyde.

determine qualitatively the nature of the hydrolysis products. Qualitative chromatographic data for the butanol-aqueous ammonia developer are given in Table I and for the butanol-pyridine-water developer are given in Table II. Where found, vanillin, syringaldehyde, *p*-hydroxybenzaldehyde, vanillic acid, syringic acid, ferulic acid, *p*-hydroxybenzoic acid, and *p*-coumaric acid were then determined quantitatively by the paper chromatographic and spectrophotometric procedures described previously (*1*, *2*, *3*). These quantitative data are given in Table III. Table III also records the original yield of 75% *n*-propanol extractives, the yield of neutrals after alkaline hydrolysis of the extractives, the yield of combined phenolic and acidic materials after alkaline hydrolysis of the extractives, and the yield of water-insoluble, ether-insoluble tar after alkaline hydrolysis.

EXPERIMENTAL PROCEDURE

In connection with other studies in our laboratories (*3*) it was found that 75% *n*-propanol gave a higher yield of extractives from aspenwood than did a number of other solvents, and, therefore, this solvent was employed in the present study. All extractions were performed in the same manner with air-dried sawdust containing 200 g. of sawdust on the oven-dry basis. The sawdust was packed in a large Soxhlet extractor and extracted with 75% *n*-propanol for 30 hr. The sawdust was removed from the extractor and pressed as dry as possible. The solvent obtained from the pressing operation was combined with the original extract and concentrated to a small volume under reduced pressure in a circulating evaporator. In some cases a little *n*-propanal was added to the concentrated extract to give a homogeneous solution. Solids contents were determined on the concentrated extracts. Total yields of extractives solids are given in Table III.

Hydrolysis Procedure

A sample of the 75% *n*-propanol extract containing 2.0 g. of solids was placed in a 250-ml. round-bottomed flask and evaporated to dryness under reduced pressure

Table II. Chromatographic Data for Acids and Phenols Fraction in 10:3:3 Butanol-Pyridine-Water

	10:3:3 Butanol–Pyridine–Water R_f[a]											
	0.00	0.02	0.06	0.10	0.15	0.38[b]	0.44[c]	0.56[d]	0.70	0.78[e]	0.81	0.84[f]
Salix nigra	..	..	..	..	..	X	B	C	..	X	..	X
Salix babylonica	..	..	..	X	X	X	A	..	X	X	..	X
Salix eriocephala	X	X	X	..	X	X	B	E	X	X	X	X
Populus tremuloides	..	..	..	..	..	X	A	C	..	X	..	X
Populus grandidentata	..	..	..	..	..	X	A	C	..	X	..	X
Populus tacamahaca	X	X	..	X	..	X	B	C	..	X	..	X
Populus deltoides	..	..	..	..	..	X	A	C	..	X	..	X
Populus trichocarpa	X	..	X	X	X	X	A	C	X	X	..	X
Populus alba	..	..	..	..	..	X	B	C	..	X	..	X
Populus nigra	X	..	..	..	X	X	B	C	..	X	..	X
Populus tremula	X	..	..	..	X	X	B	E	..	X	..	X
Juglans cinerea	X	X	X	X	..	X	A	..	..	X	..	X
Carya ovata	X	..	..	..	..	X	B	..	..	X	..	X
Betula lutea	X	..	..	..	..	X	A	..	X	X	..	X
Betula papyrifera	X	..	..	..	X	X	A	..	..	X	..	X
Alnus rubra	X	..	..	..	..	X	B	D	..	X	..	X
Carpinus caroliniana	X	X	X	..	X	X	A	..	..	X	..	X
Fagus grandifolia	X	X	..	X	X	X	B	..	X	X	..	X
Castanea dentata	X	X	..	..	..	X	A	..	..	X	..	X
Quercus alba	X	X	..	..	X	X	B	..	..	X	..	X
Quercus lyrata	X	X	..	X	..	X	B	..	..	X	..	X
Quercus borealis	X	X	X	..	X	X	B	..	..	X	..	X
Quercus velutina	X	X	X	X	..	X	B	..	..	X	..	X
Quercus falcata	X	X	X	X	X	X	B	..	..	X	..	X
Quercus coccinea	X	X	..	..	..	X	A	..	..	X	..	X
Quercus marilandica	X	..	X	..	..	X	B	..	..	X	..	X
Quercus catesbaei	X	X	X	..	X	X	B	..	..	X	..	X
Quercus phellos	X	X	..	..	X	X	B	..	..	X	..	X
Quercus nigra	X	X	X	X	..	X	B	..	..	X	..	X
Ulmus americana	..	..	..	..	X	X	B	..	..	X	..	X
Magnolia grandiflora	X	..	..	X	X	X	B	..	..	X	..	X
Magnolia virginiana	X	..	..	..	..	X	B	..	..	X	..	X
Magnolia fraseri	X	..	..	..	..	X	B	..	..	X	..	X
Liriodendron tulipifera	X	..	..	..	X	X	B	..	..	X	..	X
Liquidambar styraciflua	X	..	..	..	..	X	A	..	..	X	..	X
Platanus occidentalis	X	X	X	..	X	X	B	E	..	X	..	X
Acer saccharum	X	X	X	..	..	X	A	..	..	X	..	X
Acer rubrum	..	..	..	..	..	X	A	..	..	X	..	X
Acer saccharinum	X	..	..	..	..	X	A	..	..	X	..	X
Acer negundo	..	..	..	..	..	X	A	..	..	X	..	X
Tilia americana	..	..	..	..	..	X	B	..	..	X	..	X
Tilia heterophylla	X	X	X	..	..	X	B	D	..	X	..	X
Nyssa aquatica	X	..	..	..	X	X	B	..	..	X	..	X
Nyssa sylvatica	X	..	..	..	X	X	B	..	..	X	..	X
Fraxinus nigra	X	X	X	X	X	X	A	..	..	X	..	X
Catalpa speciosa	X	X	X	..	..	X	B	E	..	X	..	X

[a] R_f determined by means of bis-diazotized benzidine spray.
[b] Syringic acid.
[c] This spot may be vanillic acid or ferulic acid or both. Ferulic acid is identified by its white fluorescence under ultraviolet light. Actual composition was determined by paper chromatography in benzene-formic acid developer (*1*). A = vanillic acid; B = vanillic acid + ferulic acid.
[d] This spot may be *p*-hydroxybenzoic acid or *p*-coumaric acid or both. Actual composition was determined by chromatography in benzene-formic acid developer. C = *p*-hydroxybenzoic acid; D = *p*-coumaric acid; E = *p*-hydroxybenzoic acid + *p*-coumaric acid.
[e] This spot is positive to 2,4-dinitrophenylhydrazine and Mäule reagents and contains syringaldehyde.
[f] This spot is positive to 2,4-dinitrophenylhydrazine and Mäule reagents and contains vanillin (and *p*-hydroxybenzaldehyde if present).

in a rotating evaporator. The viscous residue was covered with 100 ml. of 4% NaOH solution, and the mixture was boiled under reflux for 8 hr. and allowed to cool. The alkaline mixture was extracted with ether, and the ether was dried and distilled to yield the neutrals fraction. Yields of neutral fractions are given in Table III.

The aqueous solution after ether extraction was acidified with dilute sulphuric acid and extracted with ether. This ether extract was dried and concentrated to a small volume to give the acids and phenols fraction. Solids determinations were made on the concentrated solutions to give the yield data found in Table III.

The acid-aqueous solution after ether extraction still contained considerable tarry material in most instances. The aqueous solution was decanted, and the tarry residue was washed several times with water by decantation. Finally, it was dissolved in ethanol, and the solids content of the ethanol solution was determined. The yield data for the water-insoluble, ether-insoluble tar are also given in Table III.

Analysis of the Acids and Phenols Fraction

The ether solutions containing the acids and phenols were chromatographed in replicate on paper and developed at 20°C. in butanol saturated with 2% aqueous ammonia, in 10:3:3 butanol-pyridine-water, in benzene saturated with formic acid, and in a 6:1:1 mixture of *n*-heptane, *n*-butyl ether, and water. The locations of spots on the developed chromatograms were determined by visual and ultraviolet examination and by spraying with bis-diazotized benzidine, 2,4-dinitrophenylhydrazine, and Mäule spray reagents. Chromatographic data for the butanol-aqueous ammonia and butanol-pyridine-water developers are given in Tables I and II, respectively. Because these two developers do not separate satisfactorily vanillic, ferulic, *p*-hydroxybenzoic, and *p*-coumaric acids (*1*) the data of Tables I and II have been amplified with data for these acids from the benzene-formic acid developed chromatograms. Similarly, because vanillin and *p*-hydroxybenzaldehyde are not separated by these developers, (*2*) the data of Table I and II have been amplified with data for

Table III. Alkaline Hydrolysis of 75% Propanol Extracts of Hardwoods

Wood: Common name	Wood: Scientific name	75% Propanol extract, %[a]	Neutrals extract, %[b]	Acids and phenols extract, %[b]	Vanillin, %[c]	Syringaldehyde, %[c]	p-Hydroxybenzaldehyde, %[c]	Vanillic acid, %[c]	Syringic acid, %[c]	p-Hydroxybenzoic acid, %[c]	p-Coumaric acid, %[c]	Ferulic acid, %[c]	Insoluble tar, %[b]
Black willow	*Salix nigra*	2.91	13.0	30.0	0.8	0.6	0.0	1.2	0.9	11.4	0.0	2.4	12.5
Weeping willow	*Salix babylonica*	5.28	16.5	16.0	2.2	1.8	0.0	1.8	1.7	6.0	0.0	0.0	4.5
Diamond willow	*Salix eriocephala*	5.52	32.0	35.0	0.5	0.4	1.2	1.0	0.7	1.0	1.9	1.6	21.5
Quaking aspen	*Populus tremuloides*	4.12	14.0	18.5	2.0	1.0	1.7	3.4	4.8	17.2	0.0	0.0	18.0
Bigtooth aspen	*Populus grandidentata*	3.42	11.5	59.5	0.8	0.4	0.0	0.7	0.7	6.8	0.0	0.0	24.0
Balsam poplar	*Populus tacamahaca*	3.50	30.5	43.0	0.4	0.3	0.0	1.0	1.7	3.8	0.0	1.0	19.0
Cottonwood	*Populus deltoides*	2.13	9.0	13.0	1.5	1.1	0.0	3.5	4.7	10.4	0.0	0.0	8.5
No. black cottonwood	*Populus trichocarpa*	2.33	21.5	21.0	1.5	0.8	0.0	3.8	2.3	28.7	0.0	0.0	22.5
European white poplar	*Populus alba*	3.38	16.5	16.5	1.4	1.1	0.0	1.5	1.7	10.0	0.0	1.2	13.5
Lombardy poplar	*Populus nigra*	3.81	16.0	32.5	0.6	0.4	0.0	2.0	1.0	6.5	0.0	2.9	21.5
European poplar	*Populus tremula*	4.60	10.0	37.0	0.5	0.4	1.3	0.8	1.0	5.5	1.7	1.0	11.0
Butternut	*Juglans cinerea*	9.46	12.5	25.5	0.5	0.4	0.0	1.5	1.4	0.0	0.0	0.0	4.0
Shagbark hickory	*Carva ovata*	4.98	7.0	18.5	1.2	1.0	0.0	2.9	5.7	0.0	0.0	1.6	14.5
Yellow birch	*Betula lutea*	1.24	30.0	16.5	1.2	1.4	0.0	5.6	5.3	0.0	0.0	0.0	23.0
Paper birch	*Betula papyrifera*	1.95	17.5	56.5	0.4	0.6	0.0	0.6	2.4	0.0	0.0	0.0	21.5
Red alder	*Alnus rubra*	2.78	7.5	16.5	1.0	1.2	0.0	4.6	7.1	0.0	1.1	5.2	39.5
American hornbeam	*Carpinus caroliniana*	2.01	8.0	16.0	1.0	0.9	0.0	3.2	2.8	0.0	0.0	0.0	48.5
Beech	*Fagus grandifolia*	1.82	12.0	34.0	1.7	2.5	0.0	3.3	2.4	0.0	0.0	5.0	31.5
Chestnut	*Castanea dentata*	8.15	0.6	14.5	1.4	1.5	0.0	3.4	1.9	0.0	0.0	0.0	9.5
White oak	*Quercus alba*	6.40	9.5	24.0	0.3	0.6	0.0	1.6	2.3	0.0	0.0	1.5	28.5
Overcup oak	*Quercus lyrata*	6.40	4.5	16.5	1.1	1.1	0.0	3.9	4.8	0.0	0.0	2.4	12.0
Eastern red oak	*Quercus borealis*	6.20	9.0	52.5	0.4	0.5	0.0	1.3	1.8	0.0	0.0	1.1	19.0
Black oak	*Quercus velutina*	6.58	3.5	19.5	1.0	0.6	0.0	1.4	5.0	0.0	0.0	1.3	7.5
Southern red oak	*Quercus falcata*	4.11	5.5	31.0	0.8	1.0	0.0	1.7	1.4	0.0	0.0	1.3	57.5
Scarlet oak	*Quercus coccinea*	6.27	2.0	8.5	2.9	4.5	0.0	7.9	9.3	0.0	0.0	0.0	5.5
Blackjack oak	*Quercus marilandica*	2.72	11.0	18.5	1.9	1.2	0.0	3.9	2.5	0.0	0.0	5.0	16.5
Turkey oak	*Quercus catesbaei*	4.75	6.0	17.0	1.3	1.0	0.0	1.5	5.2	0.0	0.0	1.3	10.5
Willow oak	*Quercus phellos*	3.07	8.5	19.0	0.9	1.0	0.0	1.8	1.7	0.0	0.0	0.7	12.0
Water oak	*Quercus nigra*	1.86	10.0	25.0	1.2	1.4	0.0	1.4	2.0	0.0	0.0	2.3	49.0
American elm	*Ulmus americana*	2.18	11.0	22.0	1.5	0.8	0.0	3.5	2.5	0.0	0.0	5.1	26.0
Southern magnolia	*Magnolia grandiflora*	1.48	10.0	21.5	1.5	1.2	0.0	2.6	3.4	0.0	0.0	2.1	50.0
Sweetbay	*Magnolia virginiana*	1.69	14.5	19.5	1.2	0.8	0.0	2.8	3.7	0.0	0.0	1.3	34.0
Fraser magnolia	*Magnolia fraseri*	2.60	6.0	22.0	1.0	1.4	0.0	3.3	4.8	0.0	0.0	3.5	57.0
Yellow poplar	*Liriodendron tulipifera*	1.63	18.0	22.0	1.0	1.0	0.0	2.6	2.7	0.0	0.0	2.0	44.5
Sweet gum	*Liquidambar styraciflua*	0.98	3.5	10.5	1.4	1.3	0.0	3.6	3.7	0.0	0.0	0.0	8.0
American sycamore	*Platance occidentalis*	1.72	15.0	29.5	0.6	0.5	0.0	5.8	2.8	0.6	12.0	11.6	24.5
Sugar maple	*Acer saccharum*	2.00	7.0	25.5	1.5	1.8	0.0	3.4	2.7	0.0	0.0	0.0	36.0
Red maple	*Acer rubrum*	2.42	9.5	21.0	1.3	1.4	0.0	3.3	2.8	0.0	0.0	0.0	48.5
Silver maple	*Acer saccharinum*	4.50	3.0	14.0	1.6	1.7	0.0	4.5	7.1	0.0	0.0	0.0	16.5
Box elder	*Acer negundo*	3.08	19.0	14.5	2.5	1.3	0.0	8.2	3.6	0.0	0.0	0.0	19.5
Basswood	*Tilia americana*	4.27	11.5	43.5	0.4	0.3	0.0	1.3	1.5	0.0	0.0	2.1	24.5
White basswood	*Tilia heterophylla*	4.64	9.0	35.0	1.8	0.8	1.3	2.8	2.5	0.0	1.9	3.6	23.0
Tupelo gum	*Nyssa aquatica*	5.15	6.0	11.5	1.5	1.4	0.0	7.2	5.3	0.0	0.0	6.7	31.0
Black gum	*Nyssa sylvatica*	1.29	13.5	25.0	1.9	1.2	0.0	3.0	3.5	0.0	0.0	5.1	12.0
Black ash	*Fraxinus nigra*	3.42	3.5	38.5	0.8	2.0	0.0	3.0	1.8	0.0	0.0	0.0	21.0
Northern catalpa	*Catalpa speciosa*	5.08	11.0	28.0	1.1	1.2	0.0	5.5	2.2	1.3	0.5	18.2	17.5

[a] Solids on basis of oven-dry wood.
[b] Solids on basis of 75% propanol extractives.
[c] Basis of solids in acids and phenols extract.

these two aldehydes from the heptane-butyl ether-water developed chromatograms.

Quantitative data found in Table III were obtained by procedures described in detail previously (*1, 2, 3*).

DISCUSSION OF RESULTS

The yields of propanol extractives of the 46 woods ranged from a low of less than 1.0% (sweet gum) to a high of almost 10% (butternut). Woods of some botanical families appear to give similar yields of extractives, but others vary considerably from species to species. The yields of neutral fractions of the extractives vary even more than do the yields of the extractives themselves. Chestnut extractives yielded only 0.6% neutrals, whereas the extractives of diamond willow comprised 32% neutrals. Much of the neutral fraction was present in the original wood as such, but a part of the neutral material present in the fraction was produced by the alkaline hydrolysis. The portion originally present in the wood was responsible for the streaking observed when the original propanol extracts were chromatographed on paper. The nature of the neutral fractions both before and after hydrolysis will be the subject matter of future papers.

The acids and phenols fraction content of the propanol extractives varied from a low of 8.5% (scarlet oak) to a high of 59.5% (bigtooth aspen). There appeared to be no family relationships in yields of this fraction. The values of Table III are on the basis of the propanol extractives. Actual yields on the basis of the wood may be obtained by using the propanol extractives yield data.

Qualitative chromatography of the acids and phenols fractions gave some interesting data (Tables I and II). As in the case of the hydrolysis of the original woods, all propanol extracts yielded vanillin, syringaldehyde, vanillic acid, and syringic acid. This finding indicates that apparently there occur in all deciduous woods extraneous materials with both guaiacyl and syringyl moieties containing side chain configurations capable of yielding both aldehyde and carboxylic acid products on hydrolysis with alkali alone without the presence of oxidizing agents. Wacek and Kratzl (*4*) synthesized a large number of model compounds for coniferous lignin and subjected these models to three well-known lignin reactions, namely, sulphonation, oxidation with nitrobenzene and alkali, and reaction with alkali alone. Model compounds with acyloin configurations in the side chain yielded vanillic acid on hydrolysis with alkali alone, whereas models with aldol or protected aldol configurations yielded vanillin under the same conditions. Wacek and Kratzl concluded from their experimental data that there exists in wood a protected preformed structural configuration approximating an aldol grouping which, in an exposed position, is highly labile and stabilizes in different ways depending on processing conditions employed. Hibbert and co-workers (*5, 6*) and Adler and co-workers (*7–10*) have demonstrated that a number of side chain configurations will isomerize to the acyloin structure in acidic aqueous and aqueous alcoholic solutions. Thus, the finding of vanillic and syringic acid indicate the probable occurrence of the acyloin structure in the propanol extract in one of its possible precursory forms.

All of the original 75% propanol extracts gave a strong purple color with phloroglucinol and hydrochloric acid. This color reaction is known to be due to *p*-hydroxycinnamyl aldehydes such as coniferyl aldehyde and sinapyl aldehyde. These two aldehydes comprise "protected aldol configurations" (*4*) and yield vanillin and syringaldehyde on treatment with alkali alone. It is possible that other configurations might also yield vanillin and syringaldehyde during the alkaline hydrolysis, and their occurrence in the original propanol extract should not be precluded.

The relationship of the 75% propanol extracts of these deciduous woods to the so-called "isolated native lignins" of these woods must be considered. Unfortunately, the solubility criteria employed by Brauns (*11*) for the purification of "isolated native lignin" from sprucewood, when applied to almost all deciduous woods, yield products with properties not representative of the lignin in these same deciduous woods. Consequently, the terms "isolated native lignin" or "Brauns' native lignin" should not be applied to such products whose only relationship to lignin is the arbitrary solubility scheme employed by Brauns for the isolation of a material from black spruce with properties representative of black spruce lignin. Recently, Freudenberg (*12, 13*) has noted that even in the case of spruce, the "isolated native lignin" was not representative of spruce lignin. In any event, the materials that would be extracted from all these deciduous woods by the Brauns' solvent scheme and would give the color reactions for lignin are present in the 75% propanol extracts. Whether these materials are low-molecular weight lignin materials, precursors of lignin in the wood, or other materials must await further investigation. Freudenberg (*13*) concluded that the components of Brauns' "isolated native lignin" do not participate in the formation of lignin and are possibly deposited in the wood later, independently of the formation of lignin. He indicated that they might belong to the resin system. Whatever system these compounds belong to, they apparently are present in all deciduous woods.

In addition to vanillin, syringaldehyde, vanillic acid, and syringic acid the propanol extract of every wood yielded a spot with butanol-ammonia R_f 0.27 and having carbonyl and syringyl activity as indicated by positive tests with the 2,4-dinitrophenylhydrazine and Mäule reagents, respectively. The nature of this compound has not been determined as yet, and nothing can be said of its relationships to other compounds present.

The qualitative data of Tables I and II indicate several other facts which might be of interest in taxonomic classifications. Of all the woods tested, only *Salix babylonica* and *Ulmus americana* did not yield a spot with butanol-ammonia R_f 0.00. The *Salix babylonica* is thus different in another way from the other two *Salix* species investigated. The appearance of other spots for only certain members of a particular genus or family make possible other differentiations. The big differences in the ferulic and *p*-coumaric acid contents and in the *p*-hydroxybenzaldehyde contents noted in all three tables serve as other means of differentiation of individual members of a particular genus or family.

Para-hydroxybenzaldehyde was found in the hydrolyzates of the extracts of the same four woods which yielded the compound upon direct wood hydrolysis (*2*). The related *p*-coumaric acid, on the other hand, was ob-

tained from the extracts of only six of the ten woods which yielded the acid upon direct hydrolysis of the woods themselves (*1*, *2*). These woods were *Salix eriocephala*, *Populus tremula*, *Alnus rubra*, *Platanus occidentalis*, *Tilia heterophylla*, and *Catalpa speciosa*. The woods which gave *p*-coumaric acid upon direct hydrolysis, but not on hydrolysis of their propanol extracts were *Populus tremuloides*, *Populus deltoides*, *Liquidambar styraciflua*, and *Fraxinus nigra*. In the case of *Populus tremuloides*, *p*-hydroxybenzaldehyde was obtained from a propanol extract which did not yield *p*-coumaric acid. This situation, which was not obtained in the study of direct hydrolysis of the representative hardwoods, indicates that a mechanism other than oxidative alkaline cleavage of *p*-coumaric acid is probably responsible for the formation of *p*-hydroxybenzaldehyde in the alkaline hydrolysis of hardwoods or their extractives. An aldol type of configuration as discussed under vanillin and syringaldehyde might play a role in the formation of *p*-hydroxybenzaldehyde.

Para-hydroxybenzoic acid was found in the alkaline hydrolyzates of the extracts of all woods which yielded the acid on direct hydrolysis of the sawdust. In previous studies (*1*, *2*) it was shown that all members of the willow (*Salicaceae*) family yielded substantial amounts of *p*-hydroxybenzoic acid upon alkaline hydrolysis of the sawdust. In addition, northern catalpa (*Catalpa speciosa*) yielded *p*-hydroxybenzoic acid, but in relatively smaller amount. In the present study, it was also found in the hydrolyzate of the propanol extract of American sycamore (*Platinus occidentalis*). The finding of *p*-hydroxybenzoic acid in the hydrolysis of the extract, but not in the hydrolysis of the original wood is probably accounted for by the fact that the amount found was very small, and gave no identifiable spot in the earlier work on the woods themselves. The occurrence of the *p*-hydroxybenzoic acid in the alkaline hydrolyzates of the woods of the *Salicaceae* family is probably due to hydrolysis of ester groups (*14*) or the like rather than to a mechanism similar to that responsible for vanillic and syringic acids such as hydrolysis of an acyloin configuration in a three-carbon side chain described above.

Ferulic acid was found in the alkaline hydrolyzates of only those woods which yielded ferulic acid when hydrolyzed directly. However, nine of the woods which yielded ferulic acid in the past yielded propanol extracts which did not yield ferulic acid on alkaline hydrolysis. These woods were *Populus grandidentata*, *Juglans cinerea*, *Betula lutea*, *Betula papyrifera*, *Carpinus caroliniana*, *Castanea dentata*, *Quercus coccinea*, *Acer saccharum*, and *Fraxinus nigra*. This was so in the cases of *P. grandidentata*, *C. dentata*, *Q. coccinea*, and *Acer saccharum* even though these four woods themselves have very high yields of ferulic acid upon alkaline hydrolysis. Thus, it is apparent that the ferulic acid-yielding moiety in some of these woods is actually attached quite firmly to the cell wall and is not subject to removal by the 75% propanol solvent at elevated temperature.

As in the case of the wood hydrolyses, the appearance of ferulic acid in the alkaline hydrolyzates of the wood extracts appears to be quite specific and should have taxonomic application in differentiating species within a genus or maybe a genus within a family. Thus, *Salix babylonica* is different from the other two willows tested (*S. nigra* and *S. eriocephala*) in that it was the only one that did not yield ferulic acid. Similarly, all of the European poplars (*Populus alba*, *P. nigra*, and *P. tremula* (yielded ferulic acid upon alkaline hydrolysis of their extracts, but of the five native *Populus* species tested, ferulic acid was obtained only from the extract of *P. tacamahaca*. Red alder (*Alnus rubra*) was the only member of the *Betulaceae* family whose extract yielded ferulic acid, whereas the wood of every member tested yielded the acid on alkaline hydrolysis. All members of the *Fagaceae* family yielded ferulic acid upon alkaline hydrolysis of the wood. In general, this was also true of the alkaline hydrolysis of the propanol extracts with two notable exceptions. The extracts of chestnut (*Castanea dentata*) and scarlet oak (*Quercus coccinea*) yielded no ferulic acid whatsoever, even though the woods themselves gave high yields of the compound under the same conditions. The extracts of all members of the *Magnoliaceae* family yielded ferulic acid, and the extracts of all members of the *Aceraceae* family gave no ferulic acid. Similarly, all other families represented by the woods tested disclosed no differences between members with respect to the ferulic acid-yielding ability of their propanol extracts.

The quantitative data of Table III indicate some important differences in the nature of the materials subject to alkaline hydrolysis in the entire woods and in the propanol extractives of these woods.

In the earlier studies on the alkaline hydrolysis of the woods (*1*, *2*) the syringaldehyde-vanillin ratio was almost always greater than 1.0 and in many instances, it was above 2.0. In the present study on the hydrolysis of the propanol extracts from these same woods, the syringaldehyde-vanillin ratio, in general, was less than 1.0, although there were several exceptions to this rule. Only in the cases of black ash (*Fraxinus nigra*), beech (*Fagus grandifolia*), and box elder (*Acer negundo*) were the syringaldehyde-vanillin ratios obtained by alkaline hydrolysis of the extractives substantially greater than the ratios of aldehydes obtained by alkaline hydrolysis of the woods.

Thus, it appears that in the propanol extracts the amount of guaiacyl moieties with side chain configurations capable of yielding vanillin on alkaline hydrolysis is greater than the amount of similar syringyl moieties which would yield syringaldehyde under the same conditions. Furthermore, the ratio of these guaiacyl groups to these syringyl groups must be much larger in the extractives than in the whole wood.

The vanillic and syringic acid yields from the extracts apparently had little relationship to similar products from the hydrolysis of the woods. Many wood extracts had much higher vanillic acid yields and others had higher syringic acid yields. Ratios of yields of these two acids in the extract hydrolyses apparently had no relationships in general to the ratios obtained on wood hydrolysis. The results appeared to be quite specific to individual species, and no generalizations could be made.

The quantitative data of Table III indicate some unusually high concentrations of several compounds in the acids and phenols fractions from the hydrolyses of some of the wood extracts. Thus, the extracts from red alder, scarlet oak, and silver maple yielded high per-

centages of syringic acid. An exceptionally high percentage (28.7) of *p*-hydroxybenzoic acid was found when the extractives of northern black cottonwood were hydrolyzed. The 18.2% of ferulic acid found in the acids and phenols fraction from the hydrolysis of northern catalpa extract was an unusual finding. American sycamore extract gave exceptionally high yields of both ferulic and *p*-coumaric acid. These high yields of individual compounds in the hydrolyzates of several of the wood extracts have led to the further investigation of these extracts as sources of possible intermediates of precursors of ligninlike materials. Results of such investigations will be published in the future.

Again, it should be noted that the results reported herein are still preliminary in nature because, in almost all cases, they reflect experimental data from single specimens of individual species. Possible variations discussed earlier (*1*) apply to the results and discussions of this paper.

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Cross Section Surveys as a Method of Evaluating the Self-Purification Capacity of a Stream

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Most stream sampling has been confined to collection of samples usually at the center of the stream or at some point which was believed to represent an average of the cross section of the stream. This has been done because of the limited availability of personnel for conduct of more comprehensive surveys. Such practices have usually provided satisfactory results in unpolluted sections of streams or at points a considerable distance below the point at which pollutional wastes were discharged to take advantage of natural mixing of wastes with the waters. Cooperative state-industry studies, completed by the Sulphite Pulp Manufacturers' Research League, Inc., and the Wisconsin Committee on Water Pollution, demonstrate that more accurate evaluation of stream purification capacity can be accomplished through detailed cross-section surveys which take into account the channeling of wastes in streams and the variable distribution of flow across a stream.

This paper concerns itself with the determination of self-purification capacity of streams on the basis of the reduction of biochemical oxygen demand (B.O.D.) discharged to streams and the variation in dissolved oxygen (D.O.) as the biochemical oxygen demand of the stream is changed. It is believed, however, that a brief outline of what happens in a stream will be of some help in arriving at an understanding of the problem. When oxidizable organic wastes are discharged to a stream, certain changes occur in the physical, chemical, and biological characteristics of the stream. Immediately below the outlet of the sewer, fresh solids will be present, there will be high turbidity with coincident shutting out of light, and the stream will tend to take on the color of the wastes. Sludge banks may also be present a short distance below the outlet sewer.

From the chemical standpoint, there will be a reduction in dissolved oxygen and an increase in carbon dioxide as well as an increase in those components characteristic of the wastes discharged. From the biological standpoint, we may find fish feeding at the outlet of the sewer, and large green plants present. There will be much bacterial activity and development of fungi clinging to the rocks, as well as protozoa suspended in the water to feed on bacteria, and aquatic earthworms working in the deposited sludge banks.

As the wastes proceed downstream, a zone of active decomposition develops. In this zone, the stream will become black in color and odors will be offensive. There will be gas bubbles rising, and rising sludges. Though the dissolved oxygen will amount to 40% of saturation at the upper and lower end of the zone, the middle of this zone will contain no dissolved oxygen and be septic. Much hydrogen sulphide, methane, ammonia, and carbon dioxide will be produced as this is the zone where the process of reduction and splitting of complex organic compounds is taking place.

Biologically, anaerobic bacteria will predominate, amounts of fungus in the central part of this zone will be reduced, and fish will be absent. At the lower end of this zone, the zone of recovery begins. In this zone the water will begin clearing, there will be no particular offensive odor, and gas ebullition will be absent. Dissolved oxygen will increase above 40% saturation, and carbon dioxide will be low. The bacteria will become victims of predators, and numerous protozoa, rotifers, and crustacea will be present. Fungi will appear in limited amounts, blue-green algae will occur, and diatoms and fresh water sponges will sometimes be found. Snails and clams will be present to feed on plankton, and larger fish will begin to appear.

As the stream enters the zone of cleaner water, the stream again becomes attractive. It is free of patho-

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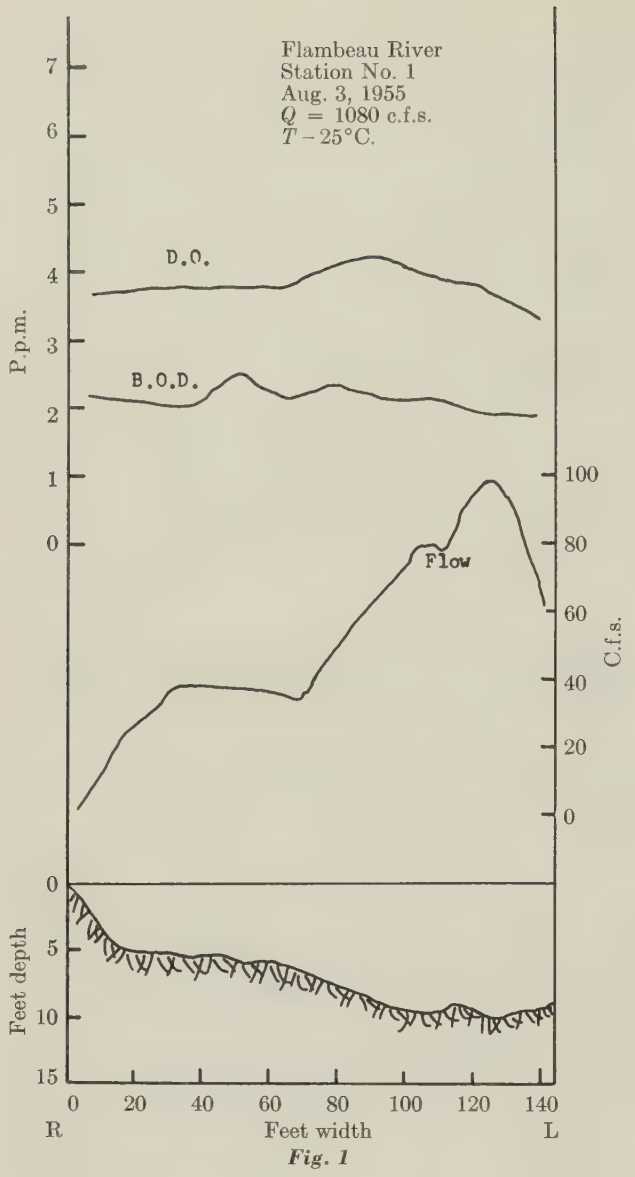

Fig. 1

gens, green plants are abundant, and the bottom sediment is clean. There will be stoneflies, burrowing mayflies, mussels and crayfish, as well as an abundance of game fish in this zone.

The four zones may not always be clear cut, and may merge into one another. In summer the zones are closer to the discharging sewer because of higher water temperatures and coincident greater activity. In winter, under ice cover, these zones may extend for many miles due to lack of reaeration and to low biological activity at low temperatures.

The effect of wastes on streams has been studied for many years and efforts have been directed toward the measurement of the self-purification capacity of streams by many researchers. Early results of the research by Streeter and Phelps in this field were published by the U. S. Public Health Service in 1925 (*1*). The early studies recognized the importance of the dissolved oxygen balance as one of the more easily determined quantitative measures capable of indicating and also of controlling the state of self-purification. The development of the "oxygen sag" concept for mathematical formulation of the oxygen balance of a stream has been a most useful tool in gaining an understanding of stream conditions and in predicting the reaction of the stream to changes in the pollution load. Substantial modifications and improvements to the original mathematical formulation and application of the oxygen sag equation have been made in the intervening years (*2–13*). The mathematical formulations aid greatly, but there is still much to be learned about the variables affecting the various constants required for effective formulation.

Most stream surveys consist of collection and analysis of a series of samples collected along the stream with one station usually above the source of pollution and the remaining stations selected at several downstream sites extending into the zone of recovery. Frequently, repeated samplings provide some information concerning what is happening in the stream. In surveys of this type it is essential that extreme care be exercised in selecting the sampling site. Such factors as the point of discharge of wastes, the channeling of wastes in a stream, the presence of dams, the inflow of fresh water from a tributary and the stratification of wastes in the stream can greatly alter the results obtained.

That is why in 1955 when the Wisconsin Committee on Water Pollution and the Sulphite Pulp Manufacturers' Research League, cooperatively, undertook a comprehensive program of stream studies, it was decided that more information of value could be obtained through cross-section studies.

These surveys are detailed in a series of reports and interpretive papers (*4–18*).

Standard operating procedure for gaging and sampling in these stream studies involved the division of the

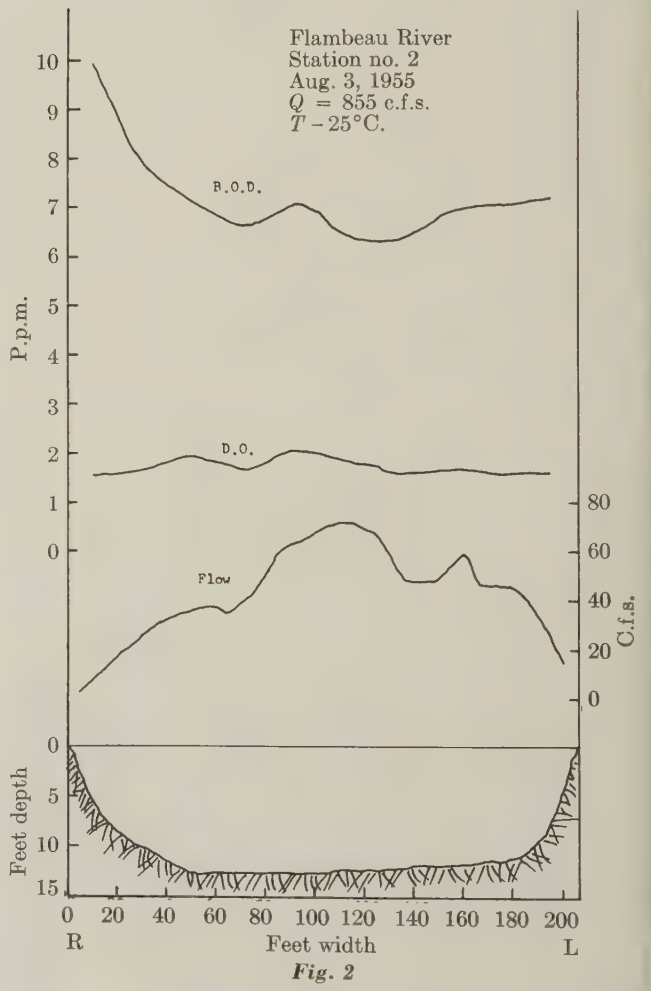

Fig. 2

width of the stream at selected stations into 20 equal sections from right to left looking downstream. The basic data that appeared necessary for a program of this type involved the determination of stream discharge, 5-day B.O.D., ultimate B.O.D., D.O., temperature, pH, and suspended solids, both fixed and volatile. With such information from individual stations obtained through multiple samplings at the stream cross sections, it was thought that it should be possible to more precisely arrive at a representative picture of stream loading, waste distribution, solids added and deposited, reaeration, oxygen utilization, and eventually also a basis for computing the self-purification capacity for given stretches of the stream.

The results of these studies have been valuable and a great deal has been gained toward achieving the original objectives of the cooperative stream study program. However, it should be understood that much still remains to be done toward development of the best methods for conducting comprehensive studies of this type and in final interpretation of the results.

A comparison of situation encountered may be of interest. Figure 1 shows cross-section determinations at a station above sources of pollution and can be considered as a section across a clean stream. There is only a slight variation in D.O. and B.O.D. and most of the flow is moving down the left bank of the stream.

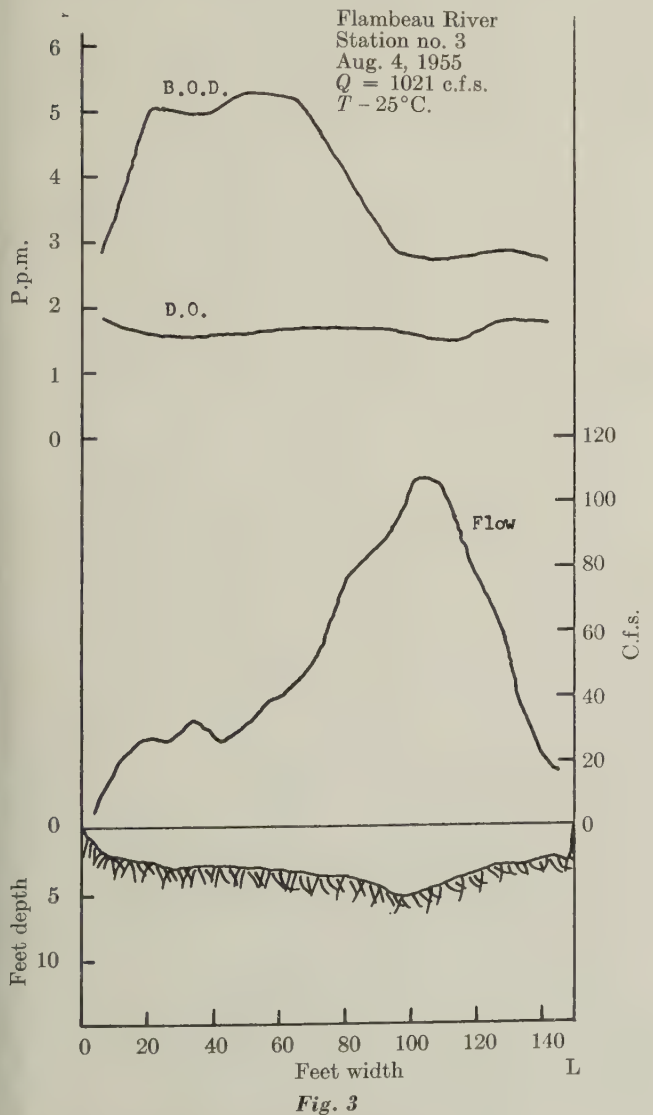

Fig. 3

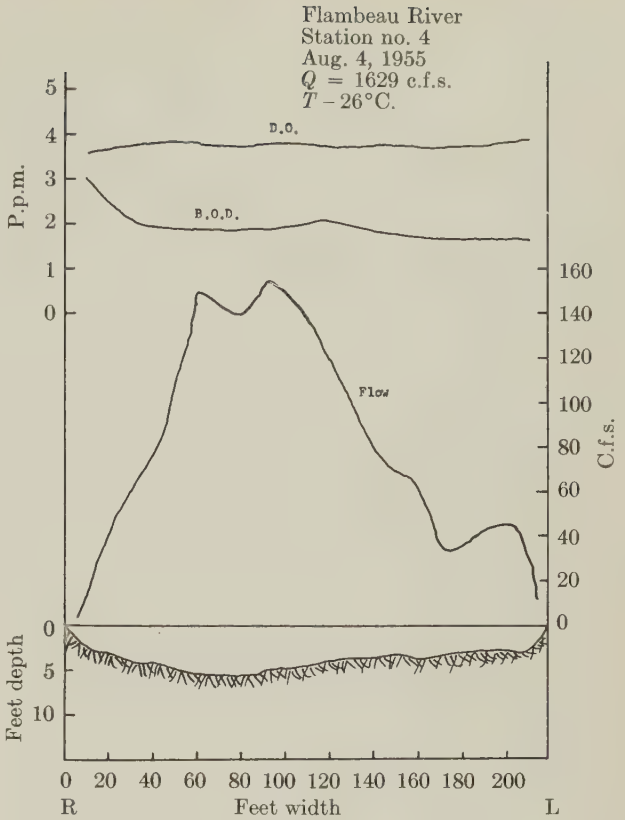

Fig. 4

A single sample taken at the center of the stream would suffice for determination of D.O. and B.O.D. but unless the average flow for this station were known, it would be necessary to measure the flow at several points across the section. This is necessary if we are to accurately calculate the pounds of D.O. and B.O.D. and arrive at a true oxygen balance.

Figure 2 shows a cross section of a stream located 3.7 miles below the source of pollution which is entering at the right bank. A power dam is located between the source of pollution and the sampling station. It should be noted that the D.O. is slightly less than at the first station but that B.O.D. has substantially increased all across the stream with high readings still occurring along the right bank. Major stream flow has shifted to the center of the stream.

As we continue downstream to a point 12.4 miles below the source of pollution, the cross section indicated in Figure 3 shows that there has been a slight change in D.O. with little variation across the stream. Most of the B.O.D. is still found in the right half of the stream though it has been somewhat reduced. Major stream flow again is near the left bank of the stream.

Figure 4 shows results obtained at the fourth cross section 24.6 miles downstream from the source of pollution. Here the dissolved oxygen is quite uniform across the stream and is beginning to approach the dissolved oxygen value of the original unpolluted station. Though the B.O.D. appears to be quite uniform across the stream, there is still some evidence of high readings along the right bank. The stream discharge is nearer center than it was at the previous station.

These figures have demonstrated the experiences encountered on a stream 140 to 200 ft. wide. On streams of greater width, another factor entered the picture. It was noted that on streams 600 to 700 ft.

Table I. Effect of Temperature on Rate of Removal of Oxygen by Known Stream Loadings

Date	River	Temp., °C.	5-day B.O.D. per c.f.s./day, lb.	D.O. at station, p.p.m.	Lowest downstream D.O., p.p.m.	B.O.D./c.f.s. per day per p.p.m. D.O. removed, lb.
10-20-55	Fox	11.0	86.5	4.5	0.17	19.97
4-28-55	Fox	13.0	41.0	10.2	8.1	19.52
6-16-55	Fox	21.7	45.0	4.8	1.4	13.23
9-3-56	Fox	21.8	32.5	7.5	6.0	21.66[a]
7-27-56	Fox	23.5	47.1	4.3	0.6	12.73
8-10-55	Wis.	24.0	54.0	5.4	0.53	11.08

[a] Test run made during mill shutdown. Heavy algae growth supplying oxygen through photosynthesis.

wide, when algae were present, there was a consistent rise in D.O. as the samplings proceeded across the stream. In the time required for sampling a cross section, about 3 hr., production of oxygen by photosynthetic activity of algae caused higher D.O. readings in the last samplings of the section than in the first samplings.

The figures show results obtained on the Flambeau River. In addition, data have been collected from well-organized cross-section studies on the lower Fox River, the Wisconsin River, and the Oconto River.

The acquisition of quantitative data on B.O.D. loading at the various stations along each of the rivers showed much evidence of the large working capacity for self-purification brought about by the various stretches of the streams between stations as the flow progressed downstream. As would be expected, the amount of work apparently accomplished varied with the season of the year, the temperature, the type of loading carried by the water, and the effect of auxiliary stream processes (such as photosynthesis by algae and the decomposition of sludge cover on the stream bottom).

A suggested method of evaluating the purification capacity of the Wisconsin streams was based on the actual stream loading in terms of pounds of 5-day B.O.D. per c.f.s. per day for each part per million of dissolved oxygen removed. These data are compiled in Table I.

The cross-section surveys afforded an opportunity to obtain accurate determinations of stream loadings at selected stations. On the Fox River these were obtained at a station above which most major sources of pollution enter the stream. It should be noted that temperatures ranging from 11 to 24°C. were encountered during the surveys. The actual loadings varied from 32.5 to 86.5 lb. of 5-day B.O.D. per c.f.s. and dissolved oxygen at the initial station ranged from 4.3 to 10.2 p.p.m. The lowest dissolved oxygen concentration downstream occurred at points from 10.1 to 17.0 miles below the initial station at which the loading was measured.

In an attempt to gain some correlation of results, the B.O.D. in the last column is expressed as the pounds of 5-day B.O.D. per day per c.f.s. per day per p.p.m. of dissolved oxygen removed. It should be noted that at low temperatures, 11.0 to 13.0°C., 1 p.p.m. of oxygen was removed at loadings of 19.52 to 19.97 lb. of 5-day B.O.D. At temperatures of 21.7 and 23.5°C., 1 p.p.m. of oxygen was removed at loadings of 12.73 to 13.23 lb. of 5-day B.O.D., and at 24°C., 1 p.p.m. of dissolved oxygen was removed at a loading of 11.08 lb. of 5-day B.O.D. In the case of the Sept. 3, 1956, survey, when the industrial pollution load was at a minimum and dissolved oxygen was increased due to photosynthesis, a high load of 21.66 lb. of B.O.D. removed 1 p.p.m. of dissolved oxygen.

It is evident from this information that at low temperatures, when the stream purification proceeds at a slower rate, considerably higher loadings can be supplied to the stream without adversely affecting downstream conditions.

For example, if it were determined that 4 p.p.m. of dissolved oxygen could be removed from a given stretch of stream without development of critical conditions, then at 11.0°C. about 80 lb. of 5-day B.O.D. per day per c.f.s. could be discharged to the stream, whereas at 23.0°C. only about 52 lb. of 5-day B.O.D. per day could be applied per c.f.s. of stream flow per day.

CONCLUSIONS

1. Single samples from polluted zones of streams are of limited value for determination of purification capacity.

2. Single samples collected from carefully selected stations in clean streams or in recovery zones where the stream flow is known may be used for evaluation.

3. Cross-section surveys of polluted streams are necessary if the information obtained is to be used for evaluation of purification capacity.

4. One method of evaluation of self-purification capacity shows that permissible loadings vary with stream temperature with higher loadings permitted at lower temperatures.

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Roller Composition in Proof Press Testing

ROBERT F. CARMACK

Reproducible proof press testing requires the control of all known variables encounterd in the printing process. At West Virginia a reproducible press testing procedure was developed using the same set of form rollers throughout the investigation. The method involved printing of paper samples with control of pressure, speed, ink film thickness, temperature, and humidity. Substitution of a new set of vulcanized corn oil rolls for the set used in developing the method produced unexpected variation in ink film thickness which was caused by the absorption of ink constituents by the new rollers. Cleaning solvents cause swelling of vulcanized corn oil rolls, which makes them unsuitable for controlled press testing. Specially compounded rolls were obtained which were free from these defects and satisfactory for proof press testing with the inks used here.

Reproducible proof press testing requires the control of all variables encountered in the printing process. Various techniques have been devised for measuring and controlling printing pressure, printing speed, ink film thickness, temperature, and humidity. Usually, however, the influence which roller composition has on the control of ink on the press has been overlooked.

At West Virginia a press testing procedure was developed using the same set of form rollers throughout the investigation. To test the reproducibility of this method, a new set of form rollers of the same composition was placed on the press; and it was the variation in ink film thickness encountered when using these new rollers which led to an inquiry into the effects of roller composition.

The technique employed to measure the variation in ink film thickness due to roller composition was based on this test method. A description of the method therefore, will precede the explanation of composition effects.

PRINT TEST METHOD

A proof press test has been developed at the West Virginia Pulp & Paper Co. for evaluating the printing characteristics of various grades of paper made in our mills. Paper samples are printed at reduced pressure and ink film thickness to magnify defects in the paper surface. The average reflectance of the printed solid image is measured and substituted in an empirical formula which calculates to a percentage value. This result gives a numerical rating for the paper sample and aids in predicting the performance of the paper in printing plants.

The reproducibility of the test method involves the control of pressure, speed, ink film thickness, temperature, and humidity. The testing apparatus is a Vandercook no. 4 proof press modified to include a pressure-sensitive base, an automatic inking device, and a timer for measuring printing speed. Ink film thickness is particularly critical and is measured by weighing aluminum foil before and after printing on it; and by controlling the stated variables, ink weights on aluminum foil are held to 31.9 ± 1.9 mg.

Pressure Control

Printing pressure is measured on a pressure-sensitive base (Fig. 1) (*1*). The base is a heat-treated, machine-surfaced steel plate mounted on two fulcrums, one at each end of the plate. A force applied at the center produces maximum deflection of the plate, which is magnified approximately 14 times by lever arms mounted at each end of the base. Attached to the upper lever arm is a dial micrometer whose sensing element contacts the lower arm; and as a force is applied to the base, the lever arms move apart activating the micrometer. (Figure 2 shows the pressure-sensitive base mounted on the press bed.) The device was calibrated to read pressure by applying known loads at the center of the base and noting the dial deflections on the micrometer. Plotting pressure versus deflections gives a calibration curve for the system.

Static pressure measurements in pounds per linear inch are taken across the 7-in. length of a 5 by 7 in. chromium-plated electrotype centrally mounted on the base. Plate height is permanently set at 0.918 in. The impression cylinder, carrying the test sheet and a backing sheet, is rotated to the center of the plate and the micrometer reading is recorded.

A standard pressure of 147 ± 3 lb. per linear in. has been selected for all papers, and variance in pressure due to stock of different weights is equalized by backing sheets placed under the test specimen. The cylinder is packed to yield a pressure of 147 lb. per linear in. when printing a 50-lb. sheet backed by a 70-lb. sheet. Conversely, a 70-lb. sheet backed by a 50-lb. sheet gives the same pressure, thus sheets of different weights may be printed simply by using the appropriate backing sheet. Therefore, with this method, no

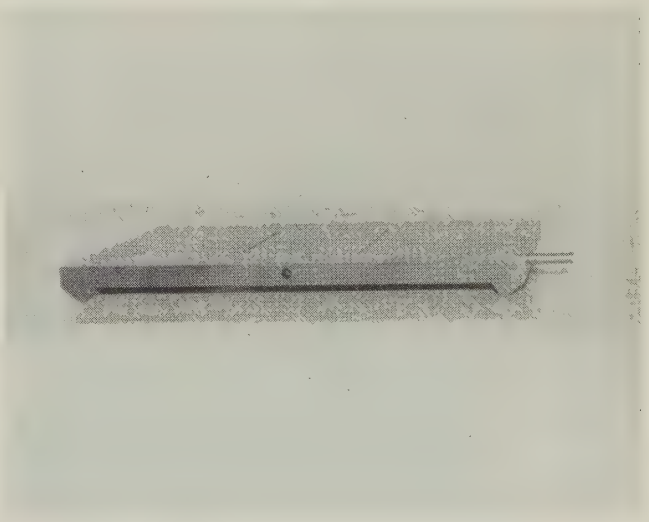

Fig. 1. Pressure-sensitive base

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change in cylinder packing is required when printing on paper of different basis weights.

Ink Control

An ink which is reproducible and which shows

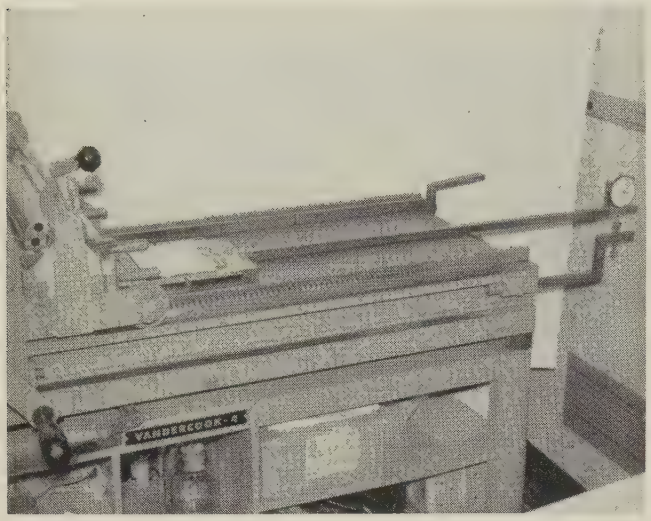

Fig. 2. Pressure measuring device

little change in properties during a press run is necessary for reproducible results by this method. Therefore, I.P.I. tack graded no. 2 ink was selected as a standard ink for our tests.

When press testing a series of papers by this method, ink film thickness on the plate available for printing is measured by printing a piece of aluminum foil and weighing it before and after.

The control of ink film thickness requires maintenance of the balance between the ink removed from the press distribution system when inking the plate, and the amount of ink added to the system to compensate for this removal. Ink put on the distribution system initially, foil weight checks on ink film thickness, and automatic ink fountain adjustments are the means by which a proper balance may be maintained.

The press in inked initially by applying 2.3000 ± 0.0010 g. of I.P.I. no. 2 tack graded ink to the distribution system and distribution it for 30 min. Aluminum foil weighings are used to check the amount of ink available initially and at intervals during the testing of a series of samples.

A clean printing plate is inked once by both form rollers for each print. The form rollers are raised when returning the carriage to the feeder end of the press, and the plate is cleaned prior to printing the next sheet; thus, the amount of ink removed from the press equals the amount applied to the plate by the form rollers.

This ink is replaced by the inker portrayed in Fig. 3 (*2*). It consists of an ink fountain, a ductor blade, an inking roll, and a rubber transfer roll. The inker rests on the bar of the carriage with the transfer roll touching the vibrator roll on the press. At the delivery end of the press, ink is transferred to the system by contact of transfer roll with inking roll. The film thickness on the inking roll has been adjusted to feed to the distribution system a quantity of ink equivalent to the amount removed when printing a sheet.

Speed

Printing speed is measured by timing the passage of the carriage over the printing plate (*3*). A microswitch connected to an electric timer is mounted at the side of the press in line with the center of the plate. The contact wheel of the switch is depressed by the 11 in. long base of the carriage. Timing this distance permits the calculation of printing velocity in feet per minute.

Temperature and Humidity

The press is in a room controlled at a temperature of 73 ± 2°F. and at a relative humidity of 50 ± 2%. All press tests are conducted under these conditions.

ROLLER COMPOSITION

During the development of the test method just described, a set of vulcanized corn oil rolls was on the press. The surface of the rolls at the start of our investigation had a dull, porous, eraserlike appearance which gradually changed through use; the rolls blackened and the surface became smooth and glazed. Then, after it had become possible to keep film thickness within 31.9 ± 1.9 mg., an unused set of vulcanized corn oil rolls was substituted for the glazed rolls in use on the press. Ten press runs were conducted to determine the effects, if any, of the new rolls on ink control. Figure 4 is a graphical representation of the fourth run which was typical.

In Fig. 4 the weight of ink on the foils is plotted as the ordinate, and the number of samples printed as the abscissa. The expected range of film thickness is indicated by the dotted lines at 30.0 and 33.8 mg. with the average at 31.9 mg. The first film thickness, at 27.2 mg., is approximately 4.7 mg. lower than the thickness obtained using the glazed rolls. Film thickness drops at the tenth position and then rises to the 31.9 mg. level.

The other nine runs gave quite similar results.

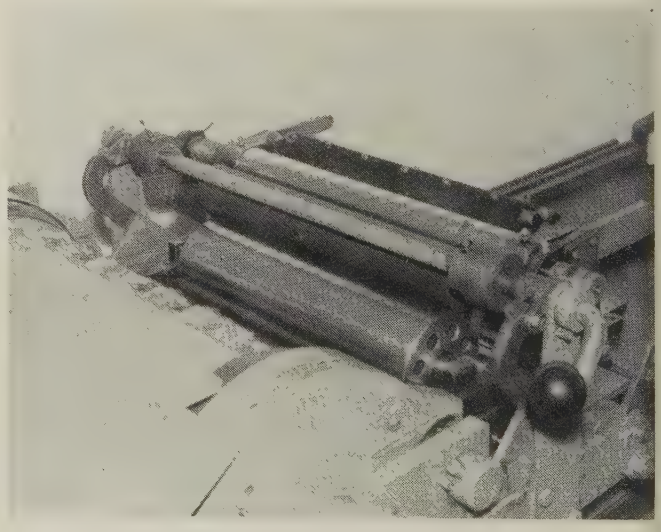

Fig. 3A. Inker—front view

The initial film thickness ranged from 25.0 to 28.0 mg. Film thickness after the first increased gradually in all cases to the 31.9 range. No trends were apparent from the first to the tenth run.

The following conclusions were drawn from the performances of the glazed set of rolls and the new set of rolls:

1. The initial low film thickness indicated that the rolls were absorbing vehicle and pigment from the ink. The rate of absorption decreased during a run, as evidenced by the rise in foil weights. At the 31.9 level absorption was at a minimum.

2. The range from 25.0 to 28.0 mg. for initial film thickness when using the new rolls indicated nonuniform absorption during the 30-min. distribution period. Variance in solvent extraction of absorbed material during cleaning could account for the observed differences. In all cases the rolls were cleaned with kerosene.

3. The old rolls had become conditioned through continued use. The blackened, glazed surface was saturated with ink particles causing very little absorption during the 30-min. distribution period. Therefore, initial film thicknesses were always close to 31.9 mg.

Several additional experiments were devised to test the above conclusions:

A. A new set of rolls was immersed in the ink vehicle for 1 week and then placed on the press, but initial film thicknesses for these rolls were in the 25.0 to 28.0 mg. range. Apparently, the rolls were not conditioned during the immersion period, and no visible change was noted in the appearance of the surface.

B. The cleaning procedure for the conditioned rolls was changed by substituting VM and P naphtha for kerosene as the solvent. The naphtha solvent cleaned the rolls completely. The surface, no longer blackened and glazed, resembled a new set of rolls. Test runs using the naphtha-cleaned rolls yielded initial film thickness varying from 25.0 to 31.9 mg. A few runs gave good reproducibility in the 31.9 mg. range. Most runs, however, had low initial film thickness with a rapid rise to the 31.9 range.

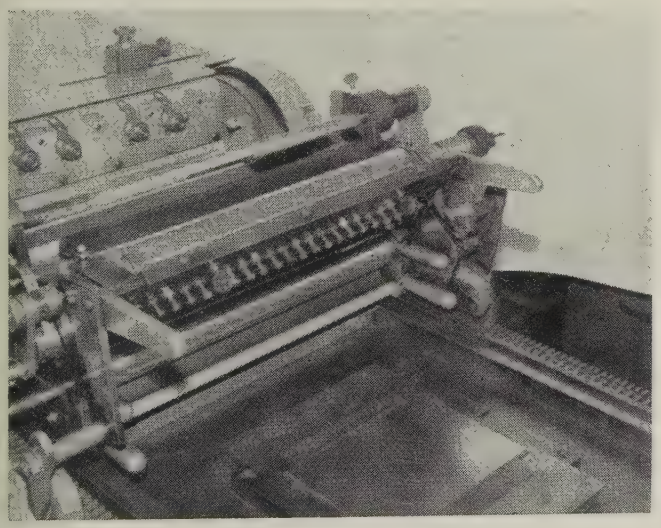

Fig. 3B. Inker—rear view

C. The cleaning procedure was again changed by replacing naphtha with kerosene. For several runs the initial film thicknesses were low. The rolls soon attained a glazed surface, however, and initial film thicknesses came up to and remained in the 31.9 mg. range.

The performance of the vulcanized corn oil rolls indicated their susceptibility to solvent action; but for a controlled press test, a roller composition relatively inert to solvent action is necessary. The problem was presented to a roller manufacturer.

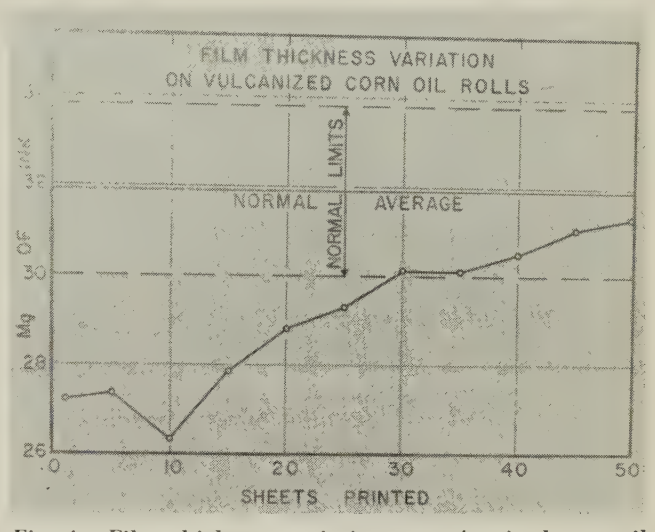

Fig. 4. Film thickness variation on vulcanized corn oil rolls

Tests performed by the manufacturer showed that the vulcanized corn oil composition swelled in the ink vehicle and swelled considerably more in the kerosene used for cleaning. Ink stability tests were performed on four different compounds. Changes in ink properties were evident after a standing period of only 6 hr. on the vulcanized corn oil rolls. The ink on a compound designated as X-T-155 was still wet after 10 days. The X-T-155 compound was suggested for use in our work.

X-T-155 compounded rolls have performed satisfactorily on our presses for two years. Sets of X-T-155 rolls have been interchanged on the press with no deviation from the established range of 31.9 ± 1.9 mg. It has also been possible to set up a similar press and procedure at The Institute of Paper Chemistry which will give comparable results.

The performance of the X-T-155 rolls has only been checked using tack-graded inks and kerosene. Inks formulated with different vehicles and cleaning solvents other than kerosene may exhibit different effects on these rolls.

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Factors Contributing to the Strength of a Sheet of Paper

I. External Specific Surface and Swollen Specific Volume

EDWARD F. THODE and WILLIAM L. INGMANSON

In an effort to integrate some of the diverse approaches to pulp evaluation, an intensive study has been made of the variation during ball mill beating of the supposedly important physical and chemical attributes of a single pulp sample. Commercial bleached sulphite pulp from a West Coast mill was employed. Separate studies were made of the following fractions, all in the never-dried state: whole pulp, pulp formed into sheets on a British handsheet mold, and pulp from which all material passing a 150-mesh screen had been removed in a Bauer-McNett classifier. In addition to the usual tests on handsheets, physical data included specific surface by five different methods and swollen volume by three different methods. The experimental results highlight the differences in the kind of "surface area" determined by the various methods for area estimation. It is shown that only the filtration resistance method (a particular type of fluid permeability method) satisfactorily accounts for the large surface area contribution of the fines fraction in beaten pulp. The regular increase in both internal and external surface with time indicates that the common laws for size reduction apply in the case of ball-mill beating of wood pulp. A good correspondence is found between the centrifuge method and the filtration resistance method for determination of the swollen specific volume of *fines-free* pulp. An analysis of the relation of external specific surface to the various strength properties of handsheets leads to the conclusion that the determination of surface area and of the distribution of surface between whole fibers and fines is principally of importance in establishing how most economically to achieve the desired strength properties through beating, refining, and the use of beater adhesives. In a different vein, it is concluded that swollen specific volume is directly related to regular tensile strength of a paper sheet through fiber plasticization effects. If a rapid method for the determination of swollen specific volume can be developed, a convenient strength prediction technique of much greater validity than the freeness test is in prospect.

At the TAPPI-CPPA Fundamental Research Conference in May, 1950, it was apparent that some of the gaps in our knowledge of fiber characteristics and their relation to paper properties resulted from a lack of integration of information on pertinent topics. In the past, virtually endless discussions have been provoked because the information on such related topics as the fines contribution to freeness, the type of surface determined by the various means of estimating external surface, the significance and location of the water bound up with the cellulose as determined by various swelling tests, and the relation of any of these to paper properties was available only on a piecemeal basis. This situation led to the decision on the part of The Institute of Paper Chemistry and its members cooperating in the Pulp Evaluation Group to undertake a series of so-called "integrated studies" on the general theme indicated by the main title of this paper. It was the privilege of one of the authors (WLI) to have a major part in outlining and coordinating the first of such studies, while both authors had a part in the obtaining of experimental data and the analysis of results. While the analysis and conclusions in this paper and the following one are solely those of the authors, the experimental program represents the thoughtful contribution of ideas and of laboratory work of a very large number of individuals.

Edward F. Thode and William L. Ingmanson, Research Associates, Chemical Engineering Group, The Institute of Paper Chemistry, Appleton, Wis.

Common wisdom tells us that an exclusive attention to the fragmentary approach to the acquisition of knowledge makes it impossible for one to visualize the whole problem. True, a problem which is too complex to solve all at once must be broken down into pieces of readily manipulated size, but too much of this leads to the situation of being unable to "see the woods for the trees."

In view of this natural pitfall, all too clearly evident in many pulp evaluation studies, the philosophy of an integrated study calls for joining together the "jigsaw pieces" of the fragmentary approach and then seeking perspective for a comprehensive view of the situation. Obviously, the pieces must fit—freeness versus burst data on southern pine kraft will not fit with external surface and swelling data on spruce sulphite—else there will be no over-all picture to view. The indicated approach to the first integrated study therefore was to obtain *not* a massive *amount* but a selected *variety* of evaluation data on a carefully delimited system and then to interrelate these data by logical means.

TECHNICAL INTRODUCTION

Surface Area

In consideration of the factors affecting the strength of a sheet of paper, there need be little doubt of the answer to the question, "Why study fiber surfaces?" The external surfaces of the dry fibers provide the only locations for potential interfiber bonding, the nature of these surfaces determines the extent and effectiveness of bonding, while areas of pits, lumen, etc., contribute their share to such paper properties as opacity.

It is important to realize at the outset that there is no specific, immutable property of a given fiber class which may be designated "*the* specific surface." Specific *external* surface is something different for each type of measurement and varies with degree of swelling of the pulp. Also, there exists in addition to the microscopically visible surfaces a much larger "*internal* surface," accessible to water molecules—and to molecules of gas in the case of dry pulps prepared by solvent exchange.

As the key portion of the first of the integrated

studies, it was felt desirable to make an extensive comparison of virtually all methods of surface area estimation of current interest. In brief review, the methods and their backgrounds are described below:

1. *Geometric Method.* The specific external surface of unbeaten fibers may be quite accurately, if tediously, determined by measurement of the perimeter of cross sections of a representative fiber population. In this study, the method of Graff, Schlosser, and Nihlen (*1*) was employed. In carrying out the present work, improved methods for the determination of population count were used.

2. *Silvering Technique.* The decomposition of hydrogen peroxide solution is catalyzed by a thin layer of silver deposited on the fibers, in the technique devised by Clark (*2*). Modifications in the method developed by Browning and Baker (*3*) and Browning (*4*) were used for this study.

3. *Filtration Resistance* (*Liquid Permeability*). By use of appropriate computational techniques, the resistance to fluid flow through a bed of packed fibers may be related to the surface area of these fibers at the hydrodynamic plane of shear. This method was employed for fixed beds by Sullivan and Hertel (*5*) and Fowler and Hertel (*6*) and brought to a high degree of accuracy by Robertson and Mason (*7*). Ingmanson (*8*), however, demonstrated advantages of employing a *dynamic bed.* For the purposes of this study, further improvements and refinements in the constant-rate filtration method were made, as described by Ingmanson and Andrews (*9*).

4. *Dye* (*Solute*) *Adsorption.* Estimation of the surface of cellulose fibers from the amount of sparingly soluble material adsorbed has been proposed by Hess and Gramberg (*10*), Stamm and Millett (*11*), and Beamesderfer, Thode, Chase, and Hubbard (*12*). The technique of the latter workers, employing the dyestuff, Benzo Fast Scarlet 4BSA (C.I. 29160), was revised for the purposes of the integrated studies as reported by Thode (*13*).

5. *Gas Adsorption.* Techniques for preparing wood pulp samples for nitrogen adsorption determinations of total specific surface (internal and external) have been greatly improved in recent years. The most recent contribution is that of Merchant (*14*). Merchant's apparatus and technique were used for the gas adsorption part of the present study, as reported in detail elsewhere by Thode, Swanson, and Becher (*15*).

6. *Optical Method.* The optical estimation of bonded area of handsheets will be considered in detail in part II of this paper.

Swollen Volume

The importance of fiber swelling in the ultimate development of strength in paper has been recognized and studied by many workers; some of the previous work most pertinent to the present investigation includes that of Kress and Bialkowsky (*16*), Jayme and Rothamel (*17*), Mason and co-workers (*18*), and Corte (*19*). The results of these many studies may be summarized in a few words; it is believed that swelling of the cellulose gel combined with dimensional swelling of the fiber results in an "opening up" of the fiber structure. It is uncertain whether or not the water which penetrates the interfiber capillaries actually helps open these capillaries. It is certain that as fiber swelling increases, the fiber structure is in a more highly plasticized state. Thus, fiber flexibility becomes greater, and greater conformability of the fibers is possible.

It is believed that this increased flexibility and plasticity leads to less fiber damage during the beating process and thus promotes more efficient wet beating. It is also reasoned that as fiber flexibility and plasticity are increased during beating, the more easily deformable fiber structure increases the interfiber contact during wet-pressing and hence leads to a greater number of potential bonding points upon drying.

In 1950, Gallay (*20*) reviewed some of the methods which have been used to measure or indicate the degree of fiber swelling; these include (1) direct microscopic measurement, (2) partial extraction, (3) dilatometric swelling, (4) centrifugation, and (5) liquid permeability measurements. Of these, the first and the last two were chosen to characterize the pulp samples in the present study. The centrifuge method used follows closely the procedure of Hopner, Jayme, and Ulrich (*21*), while the filtration resistance method described by Ingmanson and Andrews (*9*) was used for the determination of swollen volume from permeability data.

EXPERIMENTAL PROCEDURES

Sample Preparation

All measurements and observations made in the experimental work reported in this paper, parts I and II, and the supporting ones heretofore mentioned (*9*, *13*, *15*) were made on the same pulp samples in order to provide a common basis for comparison. The treatment of these samples may be outlined briefly, as follows.

The raw material used for these studies was a bleached sulphite wet-lap pulp, the as-received moisture content being 43%. Microscopic analysis showed it to have the following range of wood species: hemlock, 80 to 90%, fir, 10 to 20%, larch, trace. The pulp was shredded in a laboratory breaker before being slushed for beating.

The ball (or pebble) mill was chosen as the beating device in this problem because it minimizes fiber cutting (in this case, 1-in. porcelain balls were employed). The action is very reproducible and is primarily that of maceration or "wet beating," eliminating for the most part the effects of changing fiber length distribution on handsheet properties and thus simplifying the characterization of the changes produced in the sheets with the progress of beating. Care was taken in the charging and operation of the mill to ensure maximum reproducibility, in addition to which the samples for each beater interval were chosen as a carefully mixed composite of individual batches.

A portion of the pulp from each of the seven ball mill beating intervals (0, 20, 50, 100, 150, 200, 250 min.) was processed through a Bauer-McNett classifier with four graded screens in place. The fractions on all four screens were recombined and designated "classified pulp"; the fines fraction passing the last (150-mesh) screen was rejected. The blended pulp fractions obtained directly from ball-mill processing were designated "unclassified pulp" in contrast to the

samples described above. Both regular and wet handsheets were made from both classified and unclassified samples. The regular handsheets were made on the British machine, couched, pressed, and air-dried according to standard procedure. The wet handsheets were merely formed and couched and then redispersed in distilled water, The stock was then dewatered on qualitative filter paper in a Buchner funnel. Samples so prepared were designated "classified handsheet pulp" and "unclassified handsheet pulp," respectively. It may be readily seen that the "unclassified handsheet pulp" represented the actual fiber content of the handsheets prepared for testing of the whole (unclassified) pulp and that its fines content was necessarily intermediate between that of the whole pulp and the classified pulp (see reference (*9*) for further comments). Preparation of "classified handsheet pulp" turned out to be superfluous as its fiber distribution and properties were discovered to be essentially the same as the parent classified pulp.

Sample Evaluation

The following tests were made on all four of the above-described types of wet pulp samples from all seven beater intervals: external specific surface (silvering method), hydrodynamic specific surface (filtration resistance method), and wet fiber specific volume (filtration resistance method). The following tests were run on the straight unclassified and classified samples only from all seven beater intervals: freeness (Schopper-Riegler), handsheet drainage time, external specific surface (dye adsorption method), and cupriethylenediamine viscosity. Water-retention value (centrifuge method) was run on classified pulps only. Physical tests and evaluations run on the two sets of standard handsheets included: basis weight, caliper, apparent density, burst, tear, tensile (using Baldwin-Southwark tester), stretch, zero-span tensile, IPC velocity-viscosity product, MIT fold, Clark stiffness and rigidity, and Gurley porosity. Chemical tests performed on the classified and unclassified pulp from the 0, 100, and 250-min. intervals included alpha-cellulose, extractives, soluble lignin, and ash.

SURFACE AREA COMPARISONS

First, it is of interest to note the very close correspondence of experimental values obtained for unbeaten, classified pulp by all three of the independent methods for external surface measurement (Table I). The figures are: geometric, 7400 sq. cm. per g., silvering, 7600 sq. cm. per g., and filtration resistance, 7600 sq. cm. per g. This point was chosen for the calibration of the dye adsorption method so that the figure of 7400 sq. cm. per g. for the dye adsorption specific surface of unbeaten pulp is not significant. The points for beaten pulp by this method are independently significant, however.

Since the fibers used in the geometric study were prepared by a solvent displacement technique, they are essentially *unshrunken.** It is thus most encouraging to find such close agreement with the filtration resistance method. The validity of the computational scheme employed in the latter method is confirmed by these observations.

A glance at the data (Table I) for external specific surface area as a function of beating time for the three methods of filtration, dye adsorption, and silvering, and for both classified and unclassified pulps shows an amazing correspondence for four of the six relationships. The classified-filtration, unclassified-dye adsorption, classified-dye adsorption, and the unclassified-silvering curves appear very nearly identical (Fig. 1). To be sure, the classified filtration curve is closest to a straight line, while the others show a slight tendency to decrease at the highest beating intervals, but all four could be regarded as essentially a single curve. Not too deep a meaning should be read into this apparent fine agreement of the three diverse methods. *The* external surface area of beaten pulp fibers is still *not known*—however, we *can* say with some certainty more than was previously realized:

1. The dye adsorption and the silvering methods apparently *determine equivalent* aspects of the external surface of whole pulp. It is obviously not the same surface, else the classified silvering values would not be so divergent.

2. The dye adsorption and silvering methods determine some aspects of the surface of *whole* pulps equivalent to the hydrodynamic area of classified pulp (whole fibers with fines removed). In the case of the dye adsorption area, such surface *may* be much the same as the hydrodynamic surface, but the correspondence might also be purely fortuitous.

As well as the present methods are understood, the physical picture of exactly *what* surface each determines is not entirely clear. The generalized picture is something like this: (see sketches in Fig. 2A, 2B, and 2C; also photomicrographs of unbeaten and beaten fibers, Fig. 3A, 3B, and 3C.)

It may be seen from a comparison of the three sketches that the total volume, per gram dry fiber

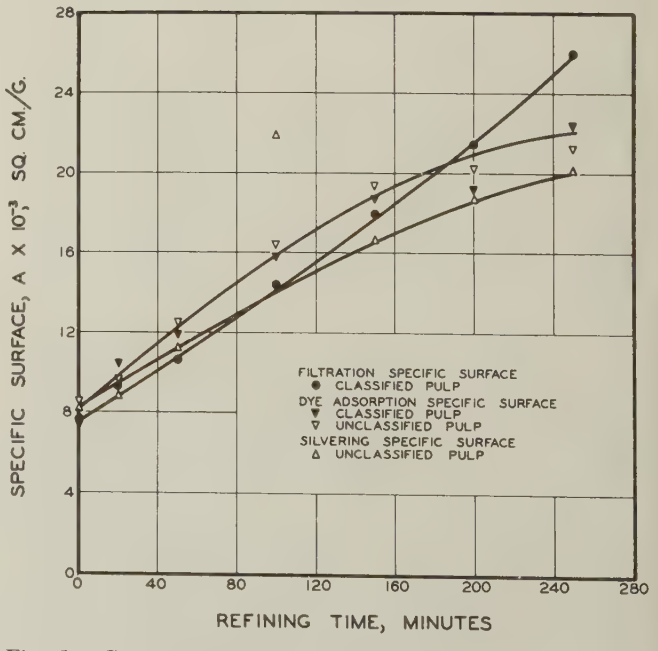


Fig. 1. Comparison of results—external specific surface as a function of beating time

* For the benefit of the reader interested in the geometric method, it should be pointed out that a typographical error in the original paper by Graff *et al.* (*1*) plus an error in abstracting that paper have led later workers to believe that the geometric method gives spuriously low values. Actually, such was never the case. A sulphite pulp, for example, in Graff's original paper actually had an indicated area of 8000 sq. cm. per g. if properly computed from his data.

Table I. Summarized Pulp Properties

	Refining time, min. 0	20	50	100	150	200	250
Pulp yield, after removal of "fines," %	93.7	89.5	89.4	83.8	78.5	76.1	77.6
Schopper-Riegler freeness, cc.							
Classified	880	870	875	840	830	800	785
Unclassified	870	800	765	520	375	230	205
Handsheet drainage time, sec.							
Classified	5.0	5.3	7.6	5.4	7.2	8.5	11.1
Unclassified	7.2	6.0	6.3	12.6	44.2	85.1	172.7
Hydrodynamic specific surface, sq. cm./g.							
Classified	7700	9150	10,450	14,100	18,200	21,300	25,200
Unclassified	10,600	17,400	22,700	37,400	52,000	63,300	79,400
Silvering specific surface, sq. cm./g.							
Classified	7650	9990	9600	11,180	10,630	11,960	10,700
Unclassified	8270	8820	11,200	20,820	16,620	18,700	20,100
Dye adsorption specific surface, sq. cm./g.							
Classified	7450	10,050	11,950	15,800	18,750	19,150	22,350
Unclassified	8500	9700	12,500	16,400	19,400	20,250	21,100
Water retention value, %							
Classified	166.1	179.1	201.3	231.3	264.1	270.5	278.9
Unclassified	156.3	...	...	...	...	...	...
Wet fiber specific volume, cu. cm./g.							
Classified	1.83	2.25	2.58	2.89	2.95	3.00	3.11
Unclassified	2.06	2.38	2.67	2.80	2.93	3.06	3.00
	Handsheet Pulp						
Silvering specific surface, sq. cm./g.							
Classified	7290	9750	6810	7580	9500	8110	10,100
Unclassified	7160	9340	9900	11,000	12,000	16,160	20,500
Hydrodynamic specific surface, sq. cm./g.							
Classified	7550	9400	10,700	14,800	17,700	21,100	26,750
Unclassified	10,100	13,350	17,300	28,850	39,100	54,250	76,400
Wet fiber specific volume, cu. cm./g.							
Classified	1.98	2.17	2.45	2.68	3.03	3.06	3.08
Unclassified	1.92	2.38	2.58	2.81	2.93	3.06	3.00

(enclosed by the hydrodynamic plane of shear), is larger in the filtration method (Fig. 2A) than in the other two; thus the surface on that basis must be larger. Note, however, that the finest fibrils are probably encased in the over-all water sheath surrounding a fiber so that the *individual* area contribution of these may be lost in the filtration resistance experiments. On the other hand, the semigelatinized "webs" of wall material visible in the photograph, Fig. 3C, must contribute enormously to filtration resistance of unclassified stocks.

Turning to the silvering representation (Fig. 2C), we may see that the fiber is somewhat shrunken by the deswelling effect of high temperature and that the silvering deposit has plated over fibrils and microcrevasses alike. Individual particles of fiber "fines," however, will each be plated separately and may have increased catalytic activity. One would speculate from the picture that the silvering method would be slightly low for unclassified pulp and definitely low for classified pulp. The data bear this out and also reveal the very poor precision of the silvering method. Note, for example, the very poor checks between silvering surface areas of classified pulp and the corresponding classified handsheet pulps as given in Table I.

Coming to the dye adsorption picture (Fig. 2B), note that a layer is shown entering crevasses and covering fibrils retaining fiber identity—the whole surface of the fiber is not covered, but in spots a double layer or multilayer of dye is indicated. It is believed from the experimental evidence that the dye does not take up at all on the "web" material or other debris which has lost fiber identity. By calibrating the dye adsorption against one of the other methods for unbeaten pulp, it is believed that a reasonably accurate value of area (really obtained through compensating variation in the two principal uncertain factors—failure to cover the entire surface, and tendency to form multilayers) obtains on beating for *classified* pulp. This value would be presumed to be smaller than that for the filtration resistance method because of the volume effect previously mentioned. However, the method obviously gives seriously low values for unclassified pulps.

It must appear obvious that the external specific surface of pulp is not a definable entity. The quantity obtained as a measure of specific surface must depend on the method of measurement; thus, the definition of external specific surface (of beaten pulps) is not complete without specification of the means of measurement.

The choice of a method for external specific surface determination or estimation will depend upon three major factors: (1) which definition of external surface is important to the experimental situation in which the data will be employed; (2) the precision to which the data are required; (3) the availability of apparatus and expediency with which the determination may be carried out.

In commenting on these criteria, it may be safely asserted that the filtration resistance method is the only satisfactorily precise method of general applicability. If the needed specialized apparatus is available, the time for a complete test is about the same as that for dye adsorption and less than that for silvering.

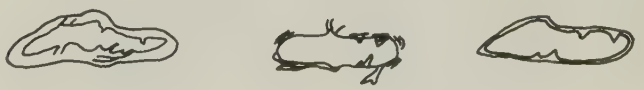
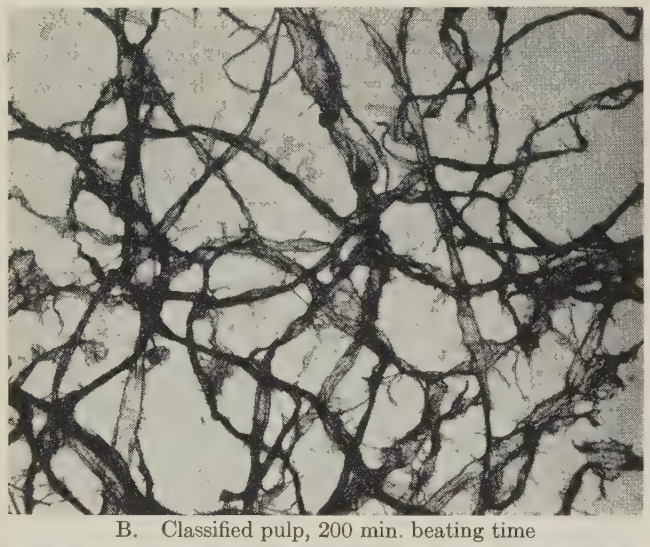


Fig. 2. Sketches of fiber surfaces outlined by different methods (a) filtration resistance; (b) dye absorption; (c) silvering

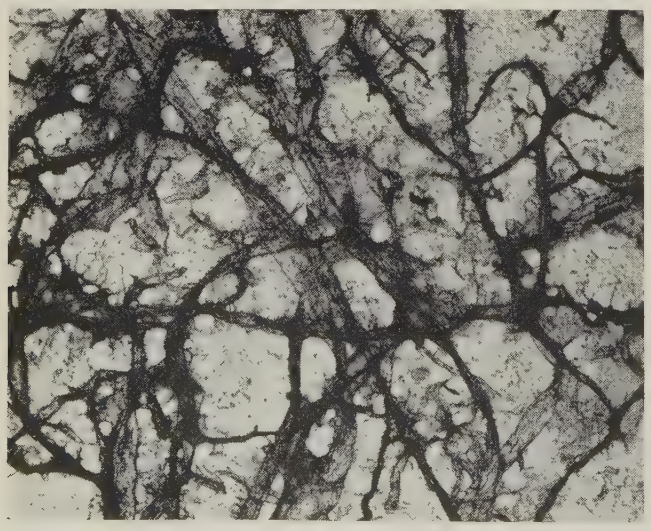
The dye adsorption test is expedient, but is limited by its characteristic of comparing effects on whole fibers only. The silvering test is inexpedient, inaccurate, and imprecise. It is not recommended for any future investigative work.

Because the filtration resistance method requires rather elaborate specialized apparatus and time-consuming calculations and because the other available methods would not be satisfactory in many cases, a need for a simple test based on the filtration resistance technique is apparent. Work is currently being planned with a view toward developing such a method.

A. Unbeaten pulp



B. Classified pulp, 200 min. beating time



C. Unclassified pulp, 200 min. beating time

Fig. 3. Photomicrographs of fibers

Increase in Surface Area with Beating

It is notable that both the external surface of the fibers in the whole pulp, that of the fiber debris, and the total (external and internal) surface of the whole fibers in the pulp increase almost linearly with beating time in the ball mill. Rittinger's law for size reduction assumes the mechanism of subdivision to be essentially that of shearing and states that the energy consumed is proportional to the fresh surface produced (*22*). Since the mechanical characteristic of the ball mill is essentially that of constant power input, the energy expended on the pulp is a direct function of time. Thus, the experimental data indicate that Rittinger's law holds almost perfectly for ball-mill beating of pulp.

It has been proposed by Higgins and Harrington (*23*) that the presence of fines in the beating operation is responsible for the "very low" efficiency of energy consumption on beating. While the energy required, *per gram of whole pulp,* to produce the surface area represented by the fines *is* larger than that required for the increase in external surface of the discrete fibers alone, both are overshadowed in order of magnitude by the energy required to produce the additional *internal* surface developed on beating! In Table II, these figures are compared (assuming Rittinger's law to hold) on the basis of 1 hr. of ball-mill beating of 1 g. of pulp.

Also, it is instructive to compare Rittinger numbers (area development per unit work input) for external and total surface with those for mineral size reduction. See Table III.

It may be seen that the ball-mill processing of pulp is no less efficient than ball-mill crushing of quartz when comparing external surface developed per unit energy input. Also, if development of *internal* surface is considered, the ball-mill processing of pulp is every bit as economical of power as the highly efficient drop weight crushing of the soft mineral, galena.

It is thus concluded that the processing of pulp is not inherently "inefficient" and that little merit attaches to the proposal that fines be removed before or during processing.

Properties Affected by External Surface

This section on surface area comparisons has dealt with surface area as such and with the considerations involved in surface area determinations. Before proceeding to the principal part of the discussion relating surface area to sheet strength, it may be desirable to summarize reasons *other than strength properties* for measuring the specific surface of pulp fibers.

Table II. Energy Requirement for Surface Area Development

	Increase in surface area, sq. m./g.	*Relative energy requirement*
External, whole fibers	0.4	1.0
External, fines	1.2	3.0
Internal, whole fibers	23.6	59.0

Table III. Rittinger Numbers for Wood Pulp and Minerals

Material	*Apparatus*	*Rittinger number, sq. cm./ft.-lb.*
Wood pulp	Ball mill	1250 (total surface)[a]
Wood pulp	Ball mill	98 (external surface)
Quartz	Ball mill	36–94[b]
Quartz	Drop weight crusher	243[b]
Galena	Drop weight crusher	1300[b]

[a] Calculated from data of Thode, Swanson, and Becher (*15*).
[b] Reference (*22*).

1. *Efficiency of Beating.* Determination of the external surface of a whole beaten pulp by the filtration resistance method coupled with a parallel determination of the external surface of the same pulp with fines removed is an excellent way of telling whether or not the refining equipment is performing its desired function. Such test would reveal if an undue amount of the refining power was going into production of fines instead of into the usually more desirable fibrillation and maceration of whole fibers.

2. *Adjustment of Dye Formulation.* The extent of surface area development and the relative areas of fines and whole fibers has a major role in establishing the depth of color and in causing two-sidedness.

3. *Retention of Sizing Agents, Wet-Strength Resins, and Beater Additives.* Retention of all these various agents is undoubtedly affected by fiber size, external surface, and fiber length distribution. Such retention is also affected by surface electrical properties and adsorption and diffusion phenomena so that the role played by surface, *per se*, is not clear. Undoubtedly, determination of external surface is needed in many investigations concerned with these phenomena.

The relation of surface to the optical properties of a sheet of paper will be examined in part II of this paper.

SWOLLEN SPECIFIC VOLUME

As was first pointed out by Mason (*18*) and later by Corte (*20*), the swollen specific volume in some respects may bear a greater influence on some strength properties than does the external specific surface. Mason showed that in one experiment the development of bursting strength of handsheets with beating closely paralleled the development of swollen volume and Corte showed a similar relation between tensile and swollen volume. Both point out that although specific surface continues to increase rapidly (almost linearly) with beating, swollen volume, after a fairly rapid initial rise, tends to level off, just as do the strength properties of tensile and burst. Both writers comment that the increased plasticity or conformability of fibers brought about by the swelling is presumably responsible for greater opportunity for bonding.

Table IV shows the results of the present investigation relating to swollen specific volume of classified pulps. The data for water-retention values as determined by a centrifuge technique have been converted to specific volume for entry in this table by considering the specific volume of water to be 1 cc. per g. and adding to the per cent water-retention value the quantity, 0.62 cc. per g. to represent the specific volume of dry cellulose. For the average of the seven beating intervals, the water-swollen specific volume calculated from the centrifuge results is only 7% higher than the hydrodynamic specific volume determined in the filtration method. This is remarkable agreement considering the difference in the two methods, but it must be emphasized that this *agreement could only be obtained on classified (fines-free) pulp.* This point deserves some comment.

Jayme and Rothamel (*17*), among the early workers with the centrifuge method, pointed out one of the inherent difficulties in the centrifuge method, namely the inability to remove interfiber water completely. With the relatively small G value (1300 × gravity) available in the equipment used for the present investigation, it was quite impossible to remove a large portion of the interfiber water from the unclassified pulp samples. On the other hand, Carroll and Mason (*24*) also report difficulty in the determination of swollen specific volume of beaten pulp by the fixed bed permeability method and were obliged to report on classified pulps only. In this investigation, it has been found that the use of the filtration resistance (dynamic bed) permeability method enabled reasonably accurate determinations of swollen specific volume of whole (unclassified) pulps over a very wide beating range.

Another limitation of the centrifuge method is the danger that *intra*fiber water will be exuded because of fiber distortion under high compacting pressures at large G values. A rough calculation indicates, however, that this factor may be of but little importance with a 0.2-g. sample below 3000 x gravity. The good correspondence between the filtration resistance and the centrifuge values of swollen volume for classified pulps are therefore taken as a very encouraging indication that eventually a centrifuge method may be devised which will accurately describe the swollen specific volume of whole pulps. Swanson and Becher (*25*) have obtained interesting and reproducible results on whole (unclassified) pulps by further modifying the basic cups described by Jayme and co-workers (*17, 21*). The present authors are now attempting to perfect a new design of cups and head for unclassified pulps capable of higher rotational forces than used in this work. If some such design can be perfected, a very rapid and convenient means of evaluating the apparently important property of swollen specific volume will be available.

To sum up this section, it has been shown that centrifuge and permeability methods for swollen volume determination agree very well where interfiber water is not a great problem. It is hoped that the relatively convenient centrifuge test can be developed for use with beaten pulps containing their normal amounts of fines.

RELATION TO STRENGTH PROPERTIES

In discussing the various strength properties of the classified and unclassified handsheets as listed in Table

Table IV. Water-Swollen Specific Volume

Beating interval, min.	*Centrifuge method, cc./g.*	*Constant rate filtration, cc./g.*
0	2.18	1.95
20	2.41	2.36
50	2.63	2.62
100	2.93	2.82
150	3.26	2.96
200	3.32	3.04
250	3.41	3.11

Table V. Handsheet Evaluation—Strength Tests

	Refining times, min. 0	20	50	100	150	200	250
Series I							
Basis weight, lb./25 × 40—500							
Classified	47.7	46.1	47.5	45.8	46.8	45.9	45.4
Unclassified	47.4	46.2	46.7	47.4	46.5	47.2	46.2
Caliper, mils							
Classified	4.0	3.4	3.3	2.9	2.8	2.8	2.7
Unclassified	3.7	3.2	3.1	2.8	2.7	2.6	2.6
Apparent density, basis weight/caliper							
Classified	12.0	13.6	14.4	15.8	16.7	16.4	16.8
Unclassified	12.8	14.4	15.1	16.9	17.2	18.2	17.8
Burst, pt./100 lb.							
Classified	47.9	78.5	88.2	100	103	109	114
Unclassified	58.9	88.1	101	106	109	102	107
Tear factor							
Classified	2.28	1.50	1.35	1.07	1.03	1.02	0.95
Unclassified	2.06	1.23	1.05	0.91	0.84	0.74	0.74
Series II							
Basis weight, lb./25 × 40—500							
Classified	47.7	46.9	47.9	46.5	46.3	45.7	46.9
Unclassified	47.4	46.4	46.9	47.8	46.6	46.4	46.8
Caliper, mils							
Classified	4.0	3.4	3.3	3.0	2.8	2.8	2.8
Unclassified	3.7	3.2	3.1	2.9	2.8	2.6	2.6
Formation, Thwing units							
Classified	50.6	50.8	35.9	38.3	28.9	30.5	34.8
Unclassified	49.2	49.7	36.6	30.5	31.5	39.7	49.8
Zero span tensile, lb./in.							
Classified	40.5	43.7	43.2	45.2	46.4	44.1	46.9
Unclassified	39.6	42.6	44.3	44.6	42.6	43.8	45.6
Baldwin tensile, lb./in.							
Classified	12.6	18.7	21.4	24.5	25.7	26.7	28.1
Unclassified	14.0	20.7	24.6	25.9	26.7	27.8	29.2
Baldwin stretch, %							
Classified	3.1	4.6	4.7	5.4	4.9	5.4	5.1
Unclassified	3.6	5.0	5.0	4.8	4.7	4.3	4.2
VVP (kp., cm./sec.)							
Classified	2.01	2.40	3.43	5.45	8.31	12.0	11.6
Unclassified	2.24	3.06	4.94	9.13	14.0	15.6	17.8
MIT fold							
Classified	26	178	412	735	1246	1179	1154
Unclassified	44	322	822	1604	3362	3069	4050

V and as shown in various of the figures to follow, let us distinguish between properties related to regular, or *x-y* tensile, strength and those related to the strength of the sheet normal to the plane of the sheet (so-called *z*-tensile*). Burst and regular tensile strength fall into the first category, while tearing strength, MIT fold, and the IPC velocity-viscosity product (VVP) are in one way or another related to the *z*-tensile. The VVP test is probably very close to being a direct indication of *z*-tensile.

In comparing pulps from the same beater interval, one is immediately struck with the fact that *x-y* tensile properties are but little affected by the removal of fines, but the *z*-tensile is markedly reduced. For example, at 200 min. beating, removal of the fines produced only a 3% reduction in regular tensile, but a 25% *increase* in tear (which is an inverse function of *z*-tensile) and a 50% *decrease* in MIT fold. These relationships are demonstrated graphically in Figs. 4, 5, and 6. If, on the other hand, pulps are compared at the same value of external specific surface (by the filtration resistance method), it may be seen that both *x-y* and the *z*-tensiles are significantly *higher* for classified pulps (whole fibers only) than for unclassified pulps (containing fines) of the same external specific surface (see Figs. 7 and 8).

Several interesting inferences and conclusions may be drawn from these observations. First, whatever it is in the fines which produces bonding appears to produce less "strength" per unit of surface available than does the equivalent in whole fibers. Second, the fines are responsible for a major portion of the *z*-tensile of the sheet, that is, that strength property which resists the "picking" out of individual fibers from the surface of the paper. Third, the fines have but little effect on regular tensile but, because they reduce

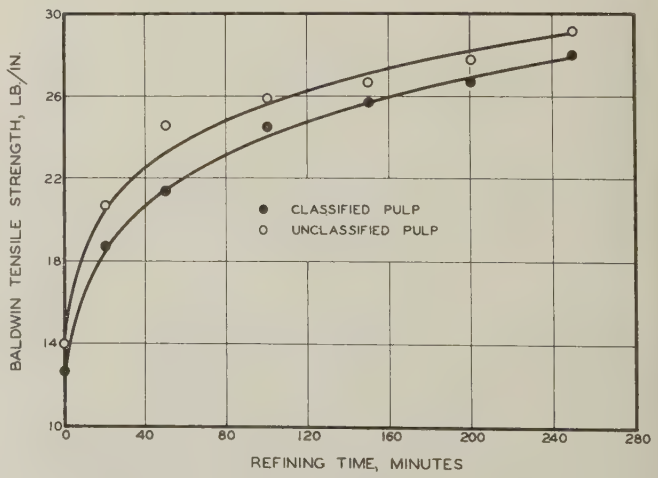


Fig. 4. Tensile strength as a function of beating time

* The term "*z*-tensile" has been adopted as a convenient term on the basis of the usual notation of coordinate axes in three dimensions. It has no relation whatsoever to zero-span tensile strength, which is essentially an indication of *fiber* strength and not of *sheet* strength.

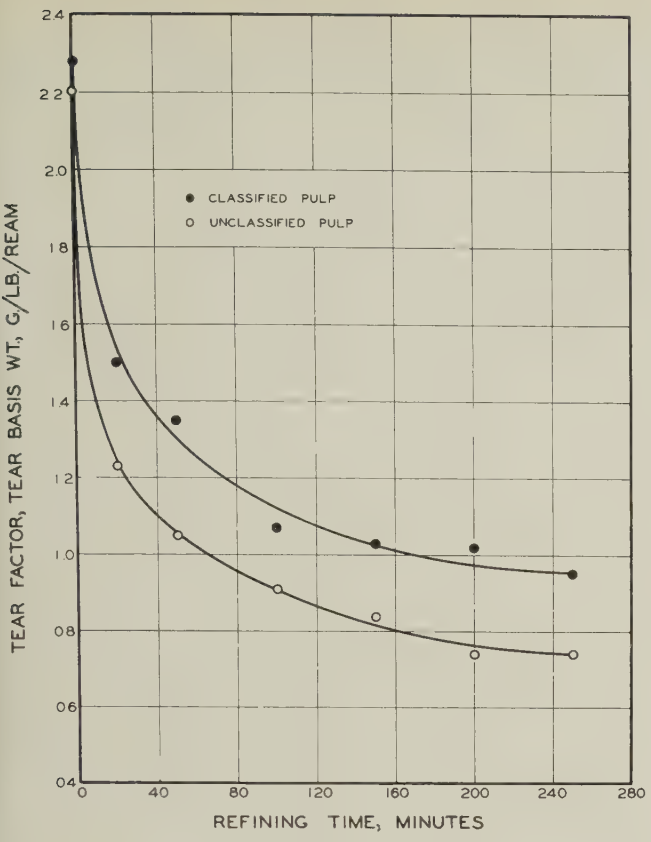


Fig. 5. Tearing strength as a function of beating time

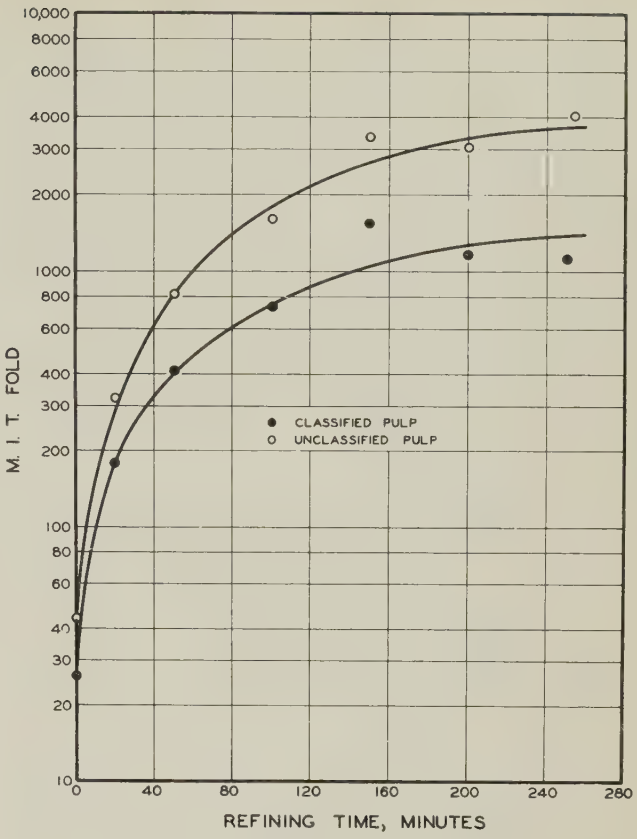


Fig. 6. Folding strength as a function of beating time

stretch, actually have a slightly detrimental effect on burst. Fourth, the removal of fines from the sheet shifts the tear-tensile criterion (a widely used empirical evaluation parameter) in the desired direction of higher tear for a given tensile.

It is not meant to imply that the discarding of fines is to be suggested as a desirable mill practice. Three objections to such general practice are obvious: (1) The fines evidently do contribute certain valuable characteristics such as high folding resistance and pick resistance. (2) It would be downright uneconomical to discard a large proportion (10 to 25%) of the fibrous raw material. (3) There is no telling, at the moment, if beater- and jordan-treated fines will behave in a manner similar to ball mill-created fines.

It is suggested, however, that these observations as to the strength contributions of fines can be of use to papermakers in controlling their beating and refining processes to minimize uneconomic production of fines. The information at hand appears to indicate that it requires the same amount of energy to produce a unit of surface in the form of fines as it does to produce a unit of surface within or on whole fibers, but such unit of surface in the form of fines is *less useful* in the production of *any* strength property than is a fiber unit.

In consequence of the above reasoning, it would seem that the determination of external surface and of the distribution of surface between fibers and fines is of importance, not so much in the direct prediction of strength properties of paper as in the determination of *how most economically to achieve those properties through beating*, refining, and the use of beater adhesives.

Although the correlation of external surface with strength properties may not be important *per se*, it is possible that the correlation of swollen specific volume with x-y tensile is important in its own right. Carroll and Mason (*24*), showed a linear correlation of tensile strength with swollen volume for samples somewhat similar to the classified pulps of the present investigation. The present data admit of such correlation for both classified and unclassified pulps. In Fig. 9 are shown results of two separate tensile tests on both classified and unclassified handsheets plotted as a function of wet fiber specific volume by the filtration resistance method. It is clear, despite the scatter from test variation, that a good linear regression curve may be fitted the respective data for classified and unclassified pulp. It also appears that the very small effect of fines makes fines loss relatively unimportant in a possible prediction correlation.

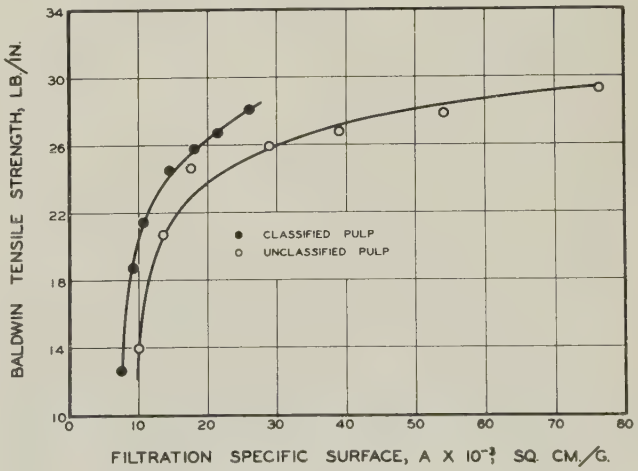


Fig. 7. Tensile strength as a function of external specific surface (filtration resistance method)

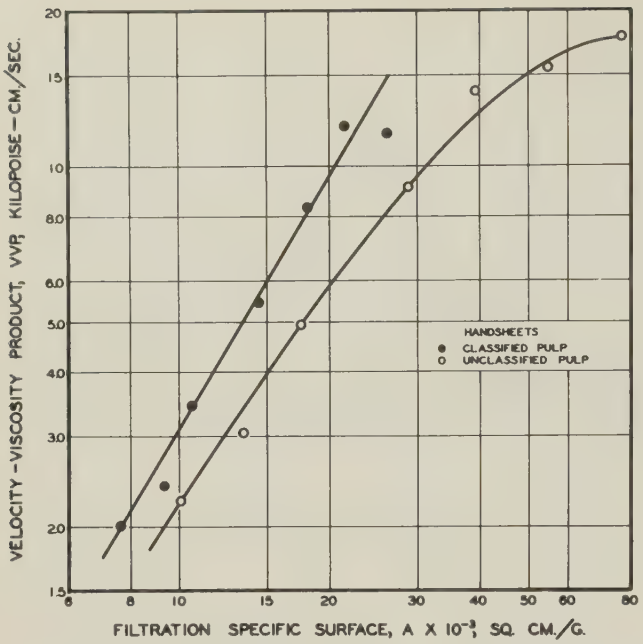

VELOCITY - VISCOSITY PRODUCT, VVP, KILOPOISE - CM./SEC.
FILTRATION SPECIFIC SURFACE, A X 10⁻³, SQ. CM./G.
HANDSHEETS
CLASSIFIED PULP
UNCLASSIFIED PULP

Fig. 8. Velocity-viscosity product as a function of external specific surface (filtration resistance method)

A more fundamental and more valuable prediction test for pulp strength than the freeness test now appears to be within reach. Freeness is not at all a good prediction of pulp strength because it depends so much upon the presence of fines for its value. For example, compare the freeness versus tensile strength data for this investigation for classified and unclassified pulp in Fig. 10. The classic remark of Clark concerning the "washing away of hydration à la Schopper-Riegler" (*26*) is yet again justified. Swollen specific *volume*, on the other hand, *is* a true measure of hydration and is apparently unaffected by fiber length distribution (see Table I, also Reference (*24*)).

Thus, if a test for swollen specific volume can be made as readily as the freeness test, a valid tool for strength prediction may be available for routine mill control use. At the moment, the swollen specific volume measurement is not rapid and convenient, but

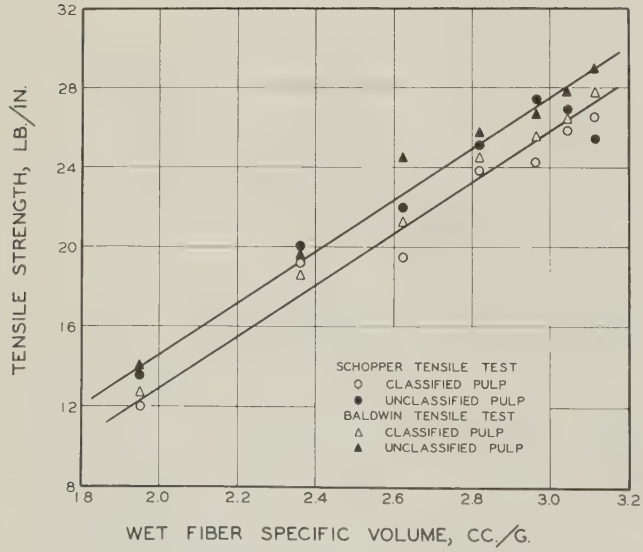


Fig. 9. Relation between tensile strength and swollen specific volume

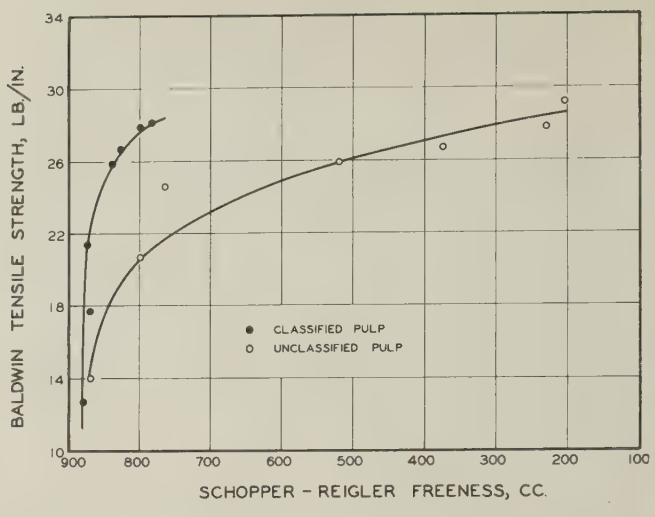


Fig. 10. Relation between tensile strength and freeness

further refinements of the centrifuge method could make it so.

As was pointed out in an earlier section, the reason why swollen specific volume should bear a basic relationship to x-y tensile is that the improved flexibility and conformability of the individual fibers which accompany swelling should lead to improved interfiber bonding. Presumably, surface tension forces in the interfiber voids during the drying of the sheet (Campbell effect) have a greater chance to draw the portions of adjacent fibers together if these fibers are rendered more plastic through swelling. Any increase in available surface which would increase the effective perimeter over which the surface tension forces could operate would also assist in the drawing together of fibers. An analysis of the interaction of these variables is presented in part II; for the moment, emphasis is placed only on the swelling effect.

CONCLUSIONS

The main conclusions of this paper may be conveniently subdivided into interpretations of the significance of external specific surface and swollen specific volume in relation to strength properties on the one hand and into critical appraisal of the techniques for determining these factors on the other.

Significance of Results

Of the two factors discussed, swollen specific volume has in itself by far the greater direct bearing on ordinary sheet tensile strength. For example, in the data presented, a linear correlation between swollen specific volume and tensile strength was observed. Of itself, external specific surface has less importance to normal tensile but is connected with pulp strength development through the distribution of surface between whole fibers and fines.

Consistent with the first conclusion, the observation of a number of previous workers is reaffirmed that the freeness test, which is principally a function of the external surface of fines, is not a significant criterion of sheet strength development.

On the other hand, the results of this investigation indicate that the fines fraction and the amount of surface of that fraction have a great bearing on strength properties related to the z-tensile of a sheet. Proper-

ties such as tear, folding resistance, and pick resistance depend a great deal upon the distribution of surface area between fines and whole fibers.

Appraisal of Techniques

Of the methods studied in this investigation, the only precise technique for obtaining the surface area of beaten pulps containing fines is the filtration resistance method. Neither the silvering technique nor the dye adsorption method satisfactorily accounts for the surface area contribution of fines. The silvering method is considered to be so difficult to perform as to be unsuitable for use in further studies.

The filtration resistance method also yields good swollen specific volume data for pulps with and without fines. Very good agreement between the centrifuge method used in this investigation and the filtration resistance method was obtained for the swollen specific volume of fines-free pulp. Data could not be obtained on beaten, whole pulps, however, by the centrifuge method. It is suggested that a modified centrifuge method which would yield reproducible results on whole pulps should prove a useful pulp evaluation tool for general use.

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Factors Contributing to the Strength of a Sheet of Paper

II. Relative Bonded Area

WILLIAM L. INGMANSON and EDWARD F. THODE

As part of an integrated study of pulp evaluation, an optical technique has been used to measure specific scattering coefficients, and the data used for estimating the relative bonded area of handsheets. Previous workers have used solvent drying to prepare unbonded handsheets to estimate the total area available for fiber bonding. It is shown that this technique gives apparently spuriously high values of relative bonded area because of the interrelated effects of fiber shrinkage and solvent surface tension. To obtain a better measure of the total dry fiber area available for bonding, strength data at different beating intervals, and various degrees of wet-pressing are correlated with the optical data. The conclusion is reached that the total *dry* fiber area available for fiber bonding which is effective in developing sheet strength remains constant with refining time, and is unaffected by the production of fines or the degree of fibrillation. Based on the concept of a constant dry fiber area, a revised technique for estimating relative bonded area is proposed. Sheet strength properties are correlated with the revised values for bonded area. The role of fiber swelling and specific surface in developing bonded area is discussed in relation to ultimate sheet strength. Estimates are made of the absolute values of fiber area obtained from optical data and are compared to previously determined values for similar fibers measured by gas adsorption with good agreement. Finally, the constancy of relative bonded area determined at different wavelengths of light imply that areas in optical contact may not be significantly different from actual bonded areas, and that the assumption of linearity between specific scattering coefficient and fiber area is reasonably valid.

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It is recognized that one of the important factors that affect paper strength is the amount of interfiber bonding that exists in a sheet of paper. The most widely used method for estimating the amount of bonded area in paper is the so-called optical technique that was originally studied by Parsons (*1*), and later explored by Ratliff (*2*). The technique was utilized by Keeney (*3*) and Leech (*4*) in their studies of paper strength. The latest and most significant contribution to our understanding of the method was made by Haselton (*5, 6*) who combined optical measurements with studies of gas adsorption determinations of the amounts of unbonded and bonded area in paper. The results of these workers have indicated the utility of the method

and have supported some of the principles of the optical technique for studying bonded area. However, evidence has also been presented that shows significant differences in the various methods for obtaining either optical data or area measurements for the total area of dry but unbonded fibers. Some of the observations made by the above investigators have been used as a framework to design a program for further investigation of bonded area in this study.

PREVIOUS WORK

Ratliff (*2*) and Haselton (*6*) have discussed the optical method in some detail and recently Swanson (*7*) has reviewed the literature related to fiber bonding. Thus, only some of the more critical assumptions and important principles will be summarized here.

The optical method utilizes numerical values of the specific scattering coefficient which may be calculated from the original theory of Kubelka and Munk (*8*, *9*). This theory quantitatively relates the scattering and absorption of light to the diffuse reflectance of a light scattering medium. The most convenient form of the theory as adapted specifically to paper has been presented in equations and charts by Steele (*10*) and Judd (*11*). Van den Akker's (*12*) suggestion that specific scattering coefficient and specific absorption coefficient be redefined in the more useful manner of a basis weight (in c.g.s. units) instead of a thickness basis has been generally followed by workers in the paper field.

By measuring two diffuse reflectances, R_0, the reflectance of a single sheet backed by a black cavity, and R_∞, the reflectance of a sheet backed by a thick pad of the same material, the scattering power, sW, may be read directly from charts. Knowledge of the basis weight of the specimen, W, permits calculation of the specific scattering coefficient, s. Since the specific scattering coefficient is a function of the wavelength of light, the reflectances are measured for monochromatic light. In this study, the General Electric recording spectrophotometer (GERS) was used.

The specific scattering coefficient, s, depends upon the size and shape of the particles in the light path and upon a function of the difference between the index of refraction of the particle and the surrounding medium. In general, s increases with decreasing particle size until the particle size approaches a small fraction of the wavelength of the incident light; thereafter, s decreases with continued decrease in particle size down to molecular dimensions. It is the dependency of s on the interfacial area between substances of different indices of refraction, i.e., fibers and air, that is utilized in the optical technique for estimating bonded area. The simplifying assumption is made that s is directly proportional to the fiber specific surface, A, (expressed on an area per unit mass basis). Thus,

$$s = kA \qquad (1)$$

where k is a dimensionless proportionality constant. When s is measured for a water-dried handsheet, it is reasoned that the area involved in fiber bonding does not scatter light, and thus s is a measure of the unbonded fiber specific surface, A_u, and specifically,

$$s_u = kA_u \qquad (1a)$$

Ratliff (*2*) has discussed the relative distances of separation of fiber surfaces that are involved in establishing fiber bonds and in creating surfaces in complete optical contact. It is known that the forces responsible for the bonding of fibers, such as hydrogen bonds and other Van der Waals forces, are effective only over distances of several Angstrom units (A) whereas complete optical contact (where no light is scattered) involves distances of a small fraction of the wavelength of the incident light, i.e., approximately 400 to 600 A. It is probable that there is no sharp line of demarcation between the presence or absence of optical contact up to perhaps several multiples of the wavelength of the incident light. However, Ratliff reasoned that if fiber surfaces were brought into proximities where optical interference could take place, the surface tension forces resulting from drying would ultimately lead to the bonding of these surfaces. It is possible, however, that the optically bonded area is greater than the true area involved in fiber bonding, and the approximate nature of equation (1a) is emphasized.

To obtain a measure of the total available surface area for fiber bonding, A_t, unbonded handsheets are formed by replacing water by acetone and then butanol (*6*). After drying, the specific scattering coefficient is determined, and equation (1) for the totally unbonded fibers becomes

$$s_t = kA_t \qquad (1b)$$

The relative bonded area (A_b/A_t) may now be estimated since the bonded area, A_b, equals the total area minus the unbonded area ($A_t - A_u$), and

$$\frac{A_b}{A_t} = \frac{s_t - s_u}{s_t} \qquad (2)$$

Leech (*4*) and Haselton (*6*) have noted that the scattering coefficient for butanol-dried spruce sulphite fibers is higher than the s value for water-dried but unbonded fibers. Haselton argued that this would be expected since the butanol-dried fibers have undergone relatively little shrinkage during drying and would correspond more closely to fibers in a water-swollen condition. Haselton used a method equivalent to extrapolating a tensile strength (at various wet-pressings) and s relationship for unbeaten fibers to zero tensile strength to obtain a correct s value for water-dried but unbonded

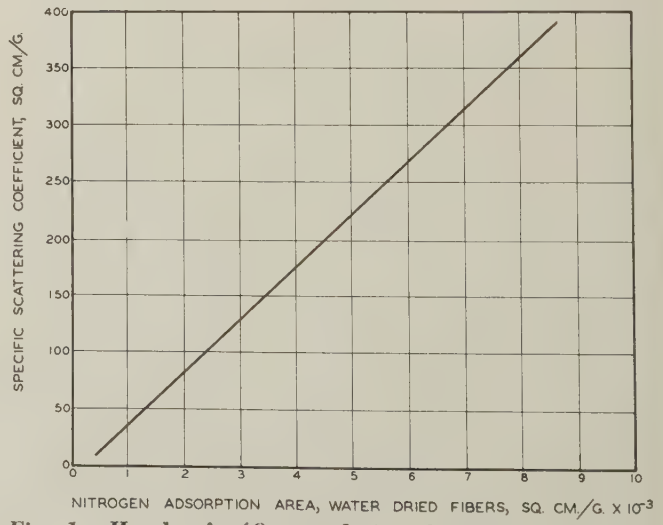

Fig. 1. Haselton's (6) correlation for bleached spruce sulphite

Table I. Scattering Coefficients and Tensile Strengths for Butanol and Water-Dried Sheets

Refining time, min.	Pressing load, lb./sq. in.	Schopper tensile strength, Unclassified	Schopper tensile strength, Classified	Specific scattering coefficient, sq. cm./g. Unclassified, mmu 650	Unclassified, mmu 550	Unclassified, mmu 450	Classified, mmu 650	Classified, mmu 550	Classified, mmu 450
0	Butanol	..	..	429	456	495	400	424	456
	0	5.4	3.6	308			285		
	1	6.7	4.5	309			302		
	10	9.5	6.4	303			294		
	25	10.5	7.7	292			280		
	50	11.5	9.0	272			273		
	150	14.7	12.3	232			238		
	Standard	13.5	12.0	242	249	267	239	249	265
20	Butanol	..	..	488	519	561	426	447	477
	0	11.8	8.8	282			273		
	1	12.2	11.2	272			262		
	10	16.9	15.9	246			238		
	25	17.7	15.6	232			239		
	50	18.4	16.8	214			221		
	150	22.2	20.9	169			184		
	Standard	21.1	19.2	189	196	208	199	206	221
50	Butanol	..	..	539	571	608	466	489	540
	0	14.4	10.8	265			261		
	1	15.9	12.0	248			246		
	10	19.1	17.3	227			224		
	25	20.2	16.9	208			218		
	50	21.6	17.6	188			198		
	150	22.9	18.3	142			158		
	Standard	22.0	19.5	162	168	179	172	181	191
100	Butanol	..	..	596	640	715	501	529	503
	0	18.4	16.7	228			231		
	1	18.2	18.2	199			206		
	5	..	22.3	..			191		
	10	21.7	23.3	157			169		
	25	23.3	22.1	157			164		
	50	24.0	23.5	134			146		
	150	26.3	..	96			..		
	Standard	25.1	23.9	119	124	134	128	133	142
150	Butanol	..	..	685	731	829	513	548	610
	0	23.1	18.8	160			216		
	1	21.2	18.1	140			191		
	5	24.6	21.7	106			173		
	10	24.8	22.4	110			163		
	25	26.1	23.4	95			142		
	50	26.1	23.6	97			122		
	Standard	27.4	24.4	74	78	83	111	115	122
200	Butanol	..	..	761	817	896	556	590	663
	0	23.6	18.3	99			202		
	1	25.0	19.1	88			177		
	5	26.7	21.7	79			163		
	10	26.3	21.7	77			148		
	25	27.5	24.2	70			127		
	50	27.4	24.7	59			113		
	Standard	26.9	25.9	56	60	64	91	95	101
250	Butanol	..	..	847	929	1055	594	623	707
	0	23.5	19.8	73			185		
	1	24.3	20.6	68			162		
	5	26.5	22.9	63			141		
	10	25.9	23.3	64			136		
	25	26.7	24.1	59			113		
	50	27.0	24.9	56			92		
	Standard	25.5	26.6	56	60	65	78	82	87

fibers. He proposed that subsequent butanol-dried s values be corrected by the same ratio of the extrapolated s to butanol s for the particular fibers in question. Since it is known that the degree of swelling of fibers is dependent upon the amount of beating (*13*, *14*), this assumption of a constant correction factor for the butanol specific scattering coefficients may be in serious error. It was decided in this study to attempt to obtain extrapolated values for s at different refining intervals using a technique of relating s values to tensile strengths at a given beating time for various degrees of wet-pressing.

Haselton (*6*) obtained a remarkable correlation between s and the area of water-dried handsheets as measured by application of the Brunauer, Emmett, and Teller equation to nitrogen adsorption isotherms. The data were precise enough to extrapolate accurately to a small positive value for area at zero s. Haselton pointed out that at 100% bonded area ($A_u = 0$), light would still be scattered at the two surfaces of a paper specimen. He estimated this point for standard handsheets as being an area of 400 sq. cm. per g. at an s value of 12 sq. cm. per g. The relationship between s_u and A_u was linear for a bleached spruce sulphite pulp at various wet-pressing and beating intervals and is shown in Fig. 1. Haselton noted that nitrogen adsorption probably does not take place on that area involved in fiber-to-fiber bonding and because of the relatively small diameter of a nitrogen molecule (4.3 A), the water-dried fiber area measured by gas adsorption is very close to the actual unbonded area of a sheet of paper. Although Haselton's correlation supports the validity of the assumption of linearity between specific scattering coefficient and fiber area, it does not preclude the possibility of optically bonded areas being greater than actual fiber bonded area.

To obtain absolute values of bonded area, the constant of equation (1) relating s to A must be established.

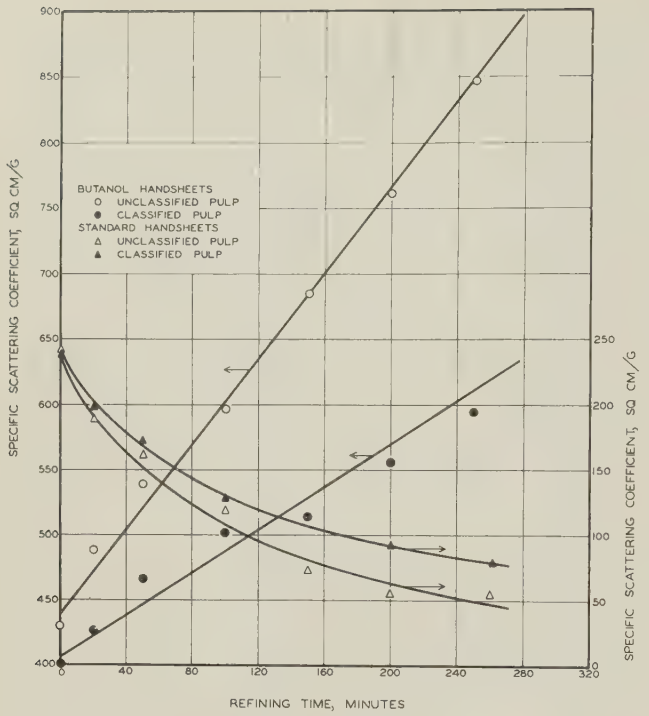

Fig. 2. Specific scattering coefficients as a function of refining time

Since Leech and Haselton have shown that differences may exist between the scattering coefficient of water-swollen and air-dried fibers, it is preferred that the correlation be made for fibers dried from water. In the past, many workers (*1–4*) have correlated the *s* values of butanol-dried fibers with specific surface of water-swollen fibers as measured by the silvering technique. Silvering data were obtained in this study for comparison with other area determinations.

EXPERIMENTAL

Specific scattering coefficients were measured for seven ball-mill refining intervals (*15*) of classified (fines removed) and unclassified (whole pulp) pulps at various degrees of wet-pressing with the GERS and using reflectance values R_0 and R_∞ at 650 mmu. At each refining interval, the water-formed handsheets were treated at seven wet pressures of from essentially zero to about 150 p.s.i. and Schopper tensile strengths were measured. In addition, *s* values were measured for the standard wet-pressed handsheets at two additional wavelengths of 450 and 550 mmu. Unbonded handsheets were obtained by displacing the water with acetone and then butanol as outlined by Haselton (*6*), and *s* values were obtained for these solvent-dried fibers. The data are given in Table I.

In addition, strength data were obtained for all the standard handsheets (*15*), surface area measured by silvering technique (*16*) and the constant-rate filtration method (*17*), wet fiber specific volumes obtained with a centrifuge method (*18*) and from filtration data (*17*). Discussion of these data and the details of pulp preparation are presented in other papers (*15, 17*).

RESULTS AND DISCUSSION

Scattering Coefficient Measurements

The specific scattering coefficients for the butanol-dried sheets and standard handsheets are related to refining time in a ball mill in Fig. 2. The *s* values for the unbonded fibers dried from butanol increase linearly with refining time but show considerably more deviation from a given functional relationship than do the scattering data for the water-dried handsheets. Experimental difficulties in the formation of unbonded handsheets probably account for these deviations since it was qualitatively observed that some of the butanol-dried sheets had appreciable tensile strengths and therefore must have been bonded, in some cases, to an unknown and uncontrolled extent. It is possible that in some instances, evaporation of butanol from the handsheet could cool the surrounding air below its dewpoint and some condensation of water vapor may have occurred. Precautions were taken to prevent excess rates of evaporation but in the transfer of butanol-saturated sheets to a controlled environment some condensation may have taken place.

The relative rate of increase of *s* for butanol-dried fibers with refining time is about double for the unclassified pulp as compared to the classified pulp. This corresponds to the ratio of the *initial* rate of increase in filtration specific surface of unclassified handsheet stock to classified stock observed by Ingmanson and Andrews (*17*). However, it was noted by these authors that the rate of change of filtration specific surface of the unclassified *handsheet* stock with respect to refining time increased with increasing refining time as the retention of fines became greater, and at high degrees of refining approached the specific surface of the *whole*, unclassified pulp. It is probable that, in the process of displacing water in handsheets with acetone and butanol, a highly beaten pulp will lose a significant amount of fines, and

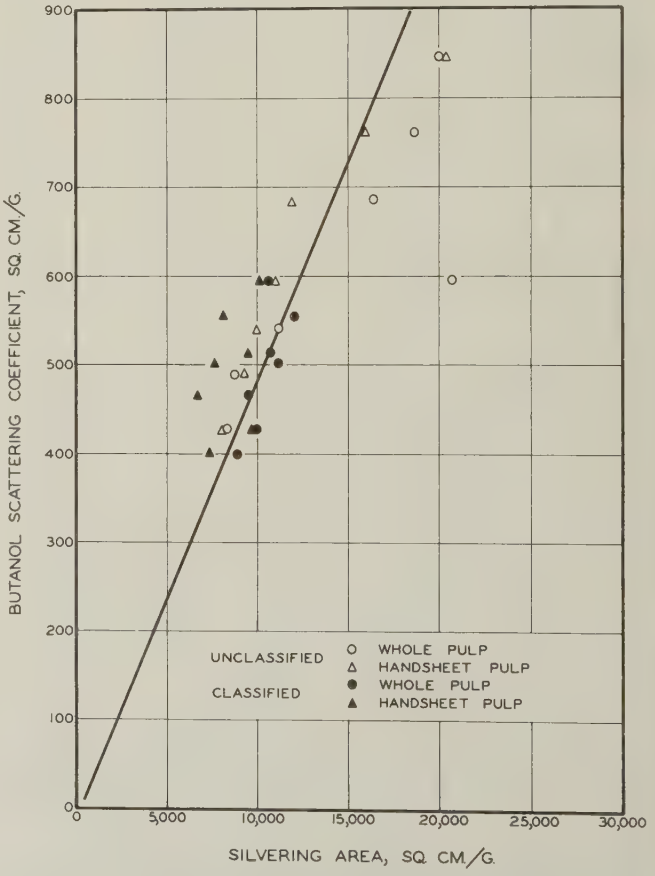

Fig. 3. Specific scattering coefficients for butanol handsheets as a function of silvering specific surface

thus, the level of scattering coefficient values will depend markedly on this unknown and uncontrolled loss. Since Fig. 2 clearly demonstrates the strong influence of fines on scattering coefficient, the significance of s values for any *unclassified* pulp is very doubtful.

The correlation between specific scattering coefficient of butanol-dried fibers and the silvering area of the fibers is shown in Fig. 3. The scatter of the data is considerable and is caused mostly by inconsistencies in the silvering areas. However, the linear correlation shown is about as good a fit as those shown by Ratliff (*2*) and Keeney (*3*). It has been noted (*17*) that there is no significant difference between the external surface area of the whole and handsheet *classified* pulp as measured by the filtration technique. This would be anticipated since fines are removed and there can be no area change because of fines loss in the formation of handsheets. However, Fig. 3 shows that the greatest difference between silvering areas at a given s value is between whole and handsheet stock of the classified pulps. Corresponding values of area for the unclassified pulps generally lie intermediate between the whole and handsheet classified stock. Therefore, the data do not justify fitting more than one curve to the points. Similar scattering of silvering data have been noted by Keeney (*3*) to be dependent upon the presence or absence of fines. It may be concluded that the increase in s for butanol-dried fibers very roughly correlates with the increase in silvering area, and the function can be approximated by a linear relationship as given by equation (1).

In Fig. 4, the specific scattering coefficient for classified butanol-dried fibers is correlated with the filtration specific surface. It is felt that the filtration technique gave the closest measure of the actual increase in area because of extensive fibrillation upon refining, and supposedly these fibrils will be available for light scattering in the butanol-dried handsheets. Since both s and the area under consideration were linear functions of refining time, they will of course, give a linear relationship when correlated together. However, the curve extrapolates to a large positive value of s for zero area. An intercept might be expected, since the butanol-dried fibers have undergone relatively little shrinkage and were known to have a large internal area as measured by nitrogen adsorption (*6*). Although most of this large internal area will not scatter appreciable light because of small distances of separation, at the very minimum it would be expected that the lumen area of the fiber and perhaps some of the largest pores would scatter light. If it is assumed that the fiber specific surfaces of equation (1) is composed of external area, A_e, measured by the filtration technique, and some unknown, but constant, internal area, A_i, then equation (1) may be written as

$$s = k(A_e + A_i) \qquad (1c)$$

and the internal area, A_i, may be estimated from the zero external area intercept of Fig. 4. This apparent internal area is about 32,000 sq. cm. per g. However, the lumen area of the fibers was estimated from microscopic measurements to be about 5000 sq. cm. per g., and thus the extrapolated value appears unreasonably high. In comparing the slopes, or k values from equation (1), in Figs. 1 and 4, about a threefold difference is observed. This threefold difference in relationships between scattering coefficient and surface area for similar fibers must be false and it is believed that the butanol-dried fibers are in a condition such that the s values do not characterize the true and full extent of fibrillation. Apparently, a significant portion of the fibrils are bonded in butanol-drying because of surface tension effects.

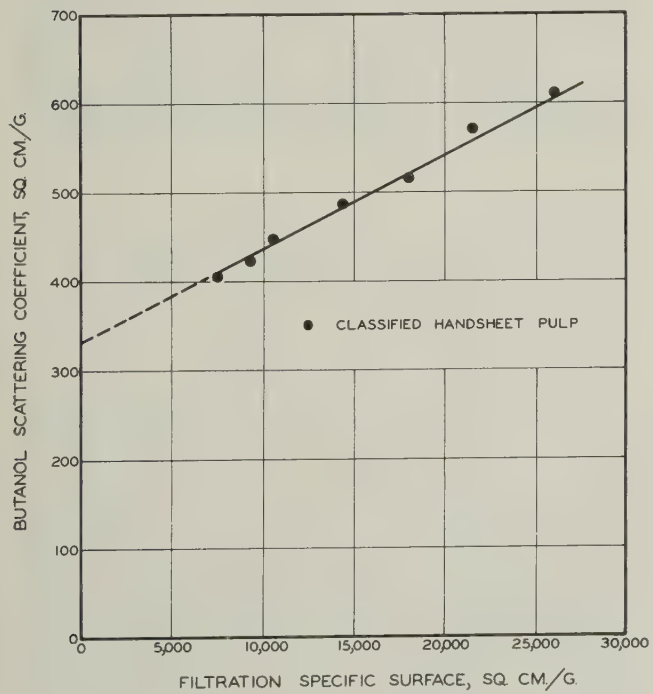

Fig. 4. Specific scattering coefficients for butanol handsheets as a function of filtration specific surface

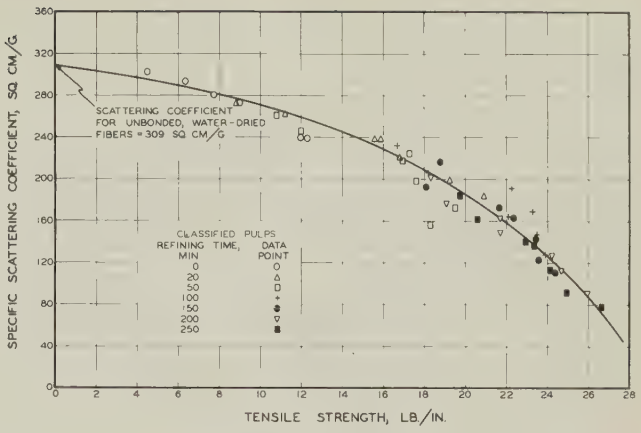

Fig. 5. Scattering coefficient-tensile strength relationship at various wet-pressing and refining intervals for classified pulps

Relative Bonded Area

To estimate relative bonded area, it is necessary to obtain a reliable measure of specific scattering coefficient (s_t) for water-dried but unbonded fibers for use in equation (2). It was planned to extrapolate tensile strength as a function of s for various degrees of wet-pressing to zero tensile strength, and it was anticipated that the data for each refining interval would extrapolate to increasingly higher s values, indicating an increase in total area available for bonding, A_t. However, examination of the data from Table I showed the relationship between s and tensile strength to be independent of the degree of beating, and the data for various degrees of

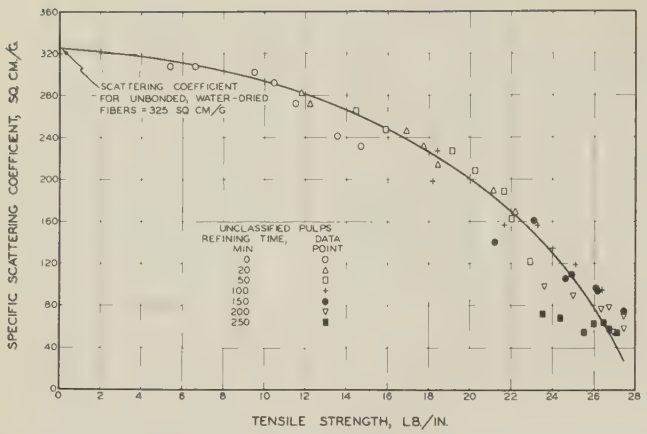

Fig. 6. Scattering coefficient-tensile strength relationship at various wet-pressing and refining intervals for unclassified pulps

wet-pressings at all refining intervals fell on one common curve as shown in Figs. 5 and 6 for classified and unclassified pulps. It should be noted that the different wet-pressing intervals permitted the data at various refining intervals to overlap, thus supporting the conclusion that the results are represented by one common curve. The deviation of the points from the given functional relationship was considered to be caused mainly by the nature of the tensile test in which failure is always at the weakest point and localized basis weight or formation variations may cause variation in the tensile strength values. A possible exception is the data for the 200 and 250-min. interval refining time of the unclassified pulp. These data show a high increase in tensile strength with relatively little decrease in scattering coefficient which is inconsistent with all the other data. Therefore, the accuracy of the tensile strength data for these two refining intervals is very questionable. It is possible that appreciable changes in sheet formation occurred as wet pressures were varied for these two slow draining pulps.

One of the remarkable features of the correlations shown in Figs. 5 and 6 is that the data indicate the total area of water-dried fibers, A_t, remains constant and is independent of the degree of refining. The specific surface of the fibers in a water-swollen state is known to increase markedly with refining because of increased fiber swelling and extensive surface fibrillation. However, when dried from water, these fibrils probably bond back to the surfaces of parent fibers. This phenomenon is shown in Fig. 7 where photomicrographs of the same individual fibers in a wet and air-dry state are given. It may be seen that the extensive fibrillation present in the wet fibers completely disappears in the dry fibers as the fibrils are rebonded to the parent fibers. In the case of the unclassified pulp where large amounts of fines were known to be present, these fines have apparently bonded on the surfaces of parent fibers with the result that the total dry fiber surface remains essentially constant. Haselton (*6*) found that the nitrogen adsorption area of bleached spruce sulphite pulp which was spray-dried to prevent bonding stayed constant at a value of about 8000 sq. cm. per g. for Valley beater intervals representing a freeness decrease of from 860 to 750 ml. S.-R. It is known that in removing fines in the fiber classification procedure some fine fibers were also removed. Thus, it is believed that the reason for the extrapolated s value for unclassified pulp being slightly higher than for classified pulp is the presence of more fine fibers with a resulting higher area.

Assuming, as the data indicate, no increase in total dry fiber specific surface, a number proportional to the bonded fiber surface, A_b, may be estimated by

$$kA_b = k(A_{tc} - A_u) = s_{tc} - s_u \qquad (3)$$

where A_{tc} and s_{tc} are assumed to remain constant at the extrapolated value. The tensile strength data for various degrees of wet-pressing at different refining intervals are correlated with the product of the proportionality constant, k, and bonded area, A_b, as given by equation (3) in Fig. 8 for classified and unclassified pulps. Constant values for s_{tc} of 309 and 325 sq. cm. per g. as determined from Figs. 5 and 6 were used in the calculations. The relationship between tensile strength and bonded area is exactly the same for both classified and unclassified pulps. These data lead to the important conclusion that at the same total bonded area, the tensile strength of the pulps are the same irrespective of degree of refining, the amount of fines, or the extent of wet-pressing. The implication is that other important factors affecting sheet strength, such as individual fiber strength, strength of fiber bonds, formation, and distribution of stress remained constant. Of course, it would also be possible for an interaction of these vari-

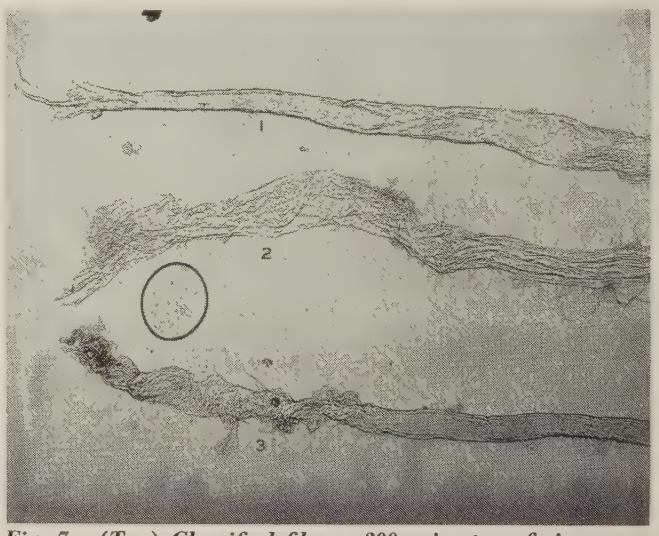

Fig. 7. (Top) Classified fibers, 200-minute refining—wet fibers. 150×

Fig. 7. (Bottom) Fibers dried from water. 150×

ables to be such that the over-all contribution to strength remained constant. However, this is an unlikely possibility since the zero-span data, formation values, and microscopic measurements of fiber lengths did not indicate any appreciable changes with beating time. Also, Nordman and co-workers (*19*) have used a modification of the optical technique to estimate bonding strength and have reported no apparent change in bonding strength with beating time for a number of pulps.

The shape of the curve relating tensile strength to total bonded area is dependent upon the relative amounts of fiber breakage and bond breakage in the tensile test. Van den Akker *et al.* (*20*) have shown that even with an unbeaten pulp (bleached sulphite), about 40% of the fibers in the zone of failure were broken, and beating to a freeness of about 320 ml. S.-R. increased the extent of fiber rupture to about 70%. Therefore, the curve of tensile strength as a function of bonded area will be one of continually decreasing slope, eventually going through a maximum and then showing a decrease in tensile strength as high degrees of mechanical degradation in the form of beating must eventually weaken the individual fiber strengths. The relationship in Fig. 8 shows that the rate of increase in tensile strength with respect to bonded area decreases as the amount of bonded area increases and fiber breakage becomes a more limiting factor. Maximum tensile strength was not reached in these studies, even with extensive ball milling of the pulps.

A different value for total bonded area may be calculated from equation (3) by assuming that the *s* values for butanol-dried fibers provide a measure of the increase in dry fiber area with refining when they are corrected by the ratio of the extrapolated *s* value to the *s* value measured directly for butanol values. This was the procedure recommended by Haselton (*6*), and the correction factor for the pulps in this study was 0.75. This

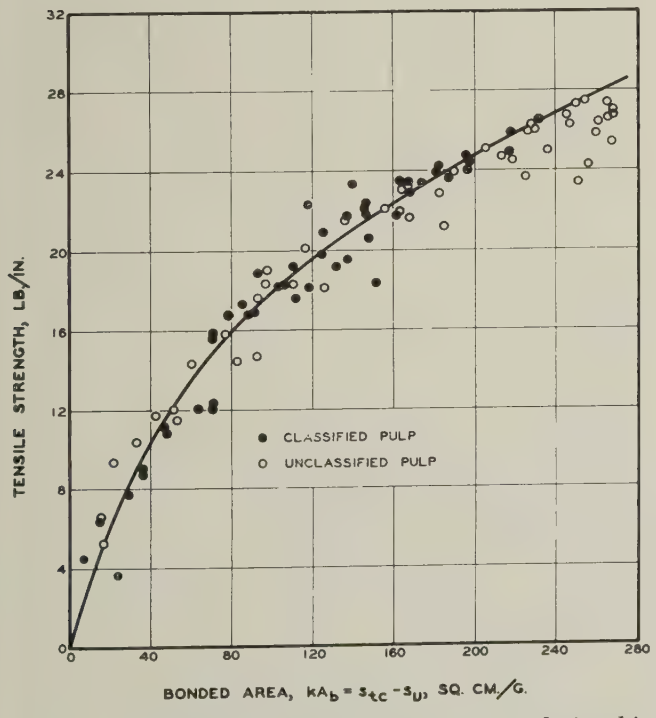

Fig. 8. Tensile strength-total bonded area relationship for various wet-pressing and refining intervals

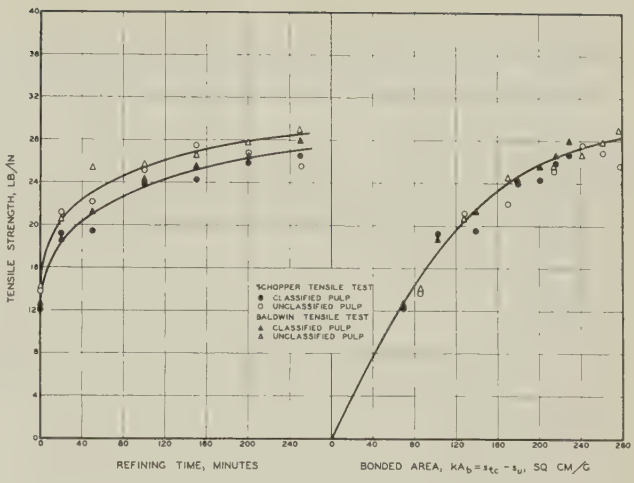

Fig. 9. Tensile strength as a function of refining time and total bonded area

type of correlation gave a distinct family of curves for the various beating intervals implying a considerable and probably unrealistic decrease in fiber strength, strength of bonds, or formation with increasing beating time. The individual curves for classified and unclassified pulps were also markedly different. It is concluded that the use of *s* values for butanol-dried fibers indicate a spuriously large increase in fiber bonding that is ineffective in contributing to sheet strength, and hence this estimate of fiber bonding does not satisfactorily represent the mechanism of strength development in paper.

When the strength properties of handsheets are related to refining time, two distinct curves are formed for classified and unclassified pulps for each particular property. If the conclusion that the total dry fiber area available for fiber bonding remains constant is valid so that equation (3) may be used to estimate bonded area, then relating a given strength property to total bonded area should reduce the curves for classified and unclassified pulps to one common curve as in Fig. 8. This has been done in Figs. 9–13 where standard handsheet data for tensile strength, velocity-viscosity product (a *z*-tensile test), tearing strength, folding strength, and apparent density are given. In every case, the strength data for classified and unclassified pulps reduce

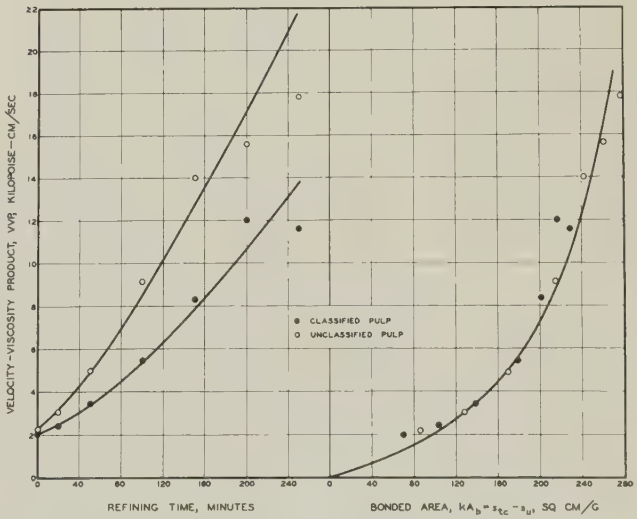
VELOCITY-VISCOSITY PRODUCT, VVP, KILOPOISE-CM./SEC
REFINING TIME, MINUTES
BONDED AREA, $kA_b = s_{tc} - s_u$, SQ CM./G
CLASSIFIED PULP
UNCLASSIFIED PULP

Fig. 10. Velocity-viscosity product as a function of refining time and total bonded area

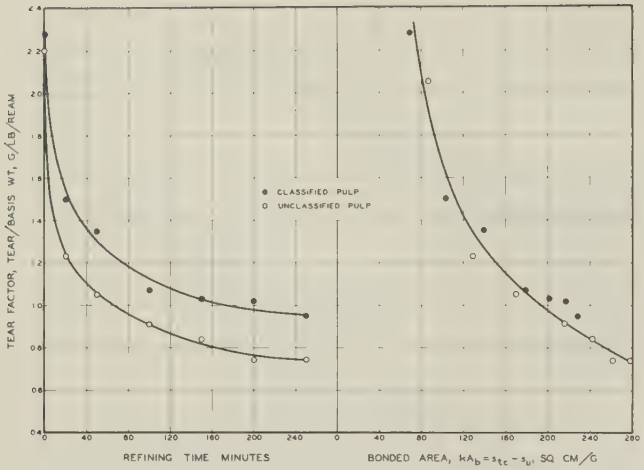
TEAR FACTOR, TEAR/BASIS WT, G/LB/REAM
CLASSIFIED PULP
UNCLASSIFIED PULP
REFINING TIME MINUTES
BONDED AREA, $kA_b = s_{tc} - s_u$, SQ CM/G

Fig. 11. Tearing strength as a function of refining time and total bonded area

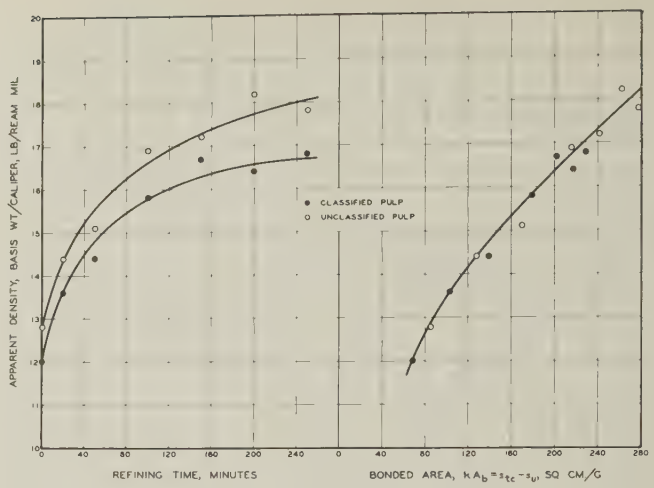
APPARENT DENSITY, BASIS WT/CALIPER, LB/REAM MIL
CLASSIFIED PULP
UNCLASSIFIED PULP
REFINING TIME, MINUTES
BONDED AREA, $kA_b = s_{tc} - s_u$, SQ CM/G

Fig. 13. Apparent sheet density as a function of refining time and total bonded area

to one common curve. It may be concluded for pulps in this study that at a given total bonded area, the strength of paper is independent of the degree of fibrillation or the amount of fines. It should be remembered that other important factors affecting strength such as fiber strength, bonding strength, fiber length, and formation all remained essentially constant in this study. The success of the correlations in Figs. 9–13 indicate that the methods suggested for calculating bonded area is correct and that this concept of bonded area has considerable utility in pulp evaluation.

A picture of strength development upon refining is suggested from the preceding analysis of the data. As a pulp is beaten, the fiber surface becomes fibrillated, fines and fiber debris are formed, and the degree of swelling of fiber increases. The only major role of fibrillation and fines in producing strength is to provide greater surface tension forces [the Campbell effect (*21*)] to draw fiber surfaces into close enough proximity for bonds to be established. The potential area available for final bonding in the dry paper is the original, unbeaten fiber surface, and hence is fixed by the original fiber diameter. By increasing the fiber swelling during beating, the fiber flexibility or conformability of the surfaces is increased, and hence given surface tension forces during drying will produce more bonded area.

The correlation between bonded area and swollen specific volume is shown in Fig. 14. It should be remembered that unclassified and classified pulps had the same specific volume at the same refining interval, but the rate of increase and level of specific surface was much higher for the unclassified pulp because of the presence of fines. Therefore, at a given specific volume, the unclassified pulp has a greater bonded area, and, hence, greater strength because of the contribution of fines in increasing the surface tension forces during drying. The concave-upward nature of the curves, showing greater increases in bonded area with respect to a given change of specific volume at higher values of specific volume, probably results because of the larger change in specific surfaces with a given change in specific volume during these latter stages of beating. Since the shape of the curves for classified and unclassified pulps are similar, and since the rate of increase of specific surface with a given change in specific volume is much greater for unclassified pulp, it appears that fines are not so effective as an equivalent surface area of fibrils in drawing fiber surfaces together for bonding.

The relative or percentage bonded area as given by the ratio in equation (2) of bonded area to total area available for bonding (A_b/A_t) may be estimated in a number of ways:

1. The original Parsons (*1*) and Ratliff (*2*) technique

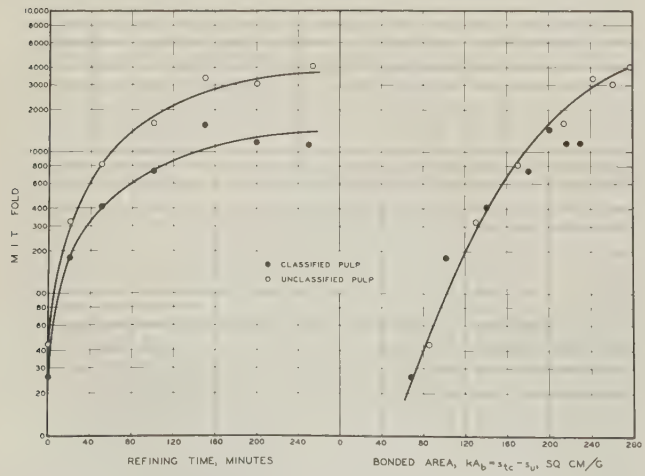

Fig. 12. M.I.T. folding strength as a function of refining time and total bonded area

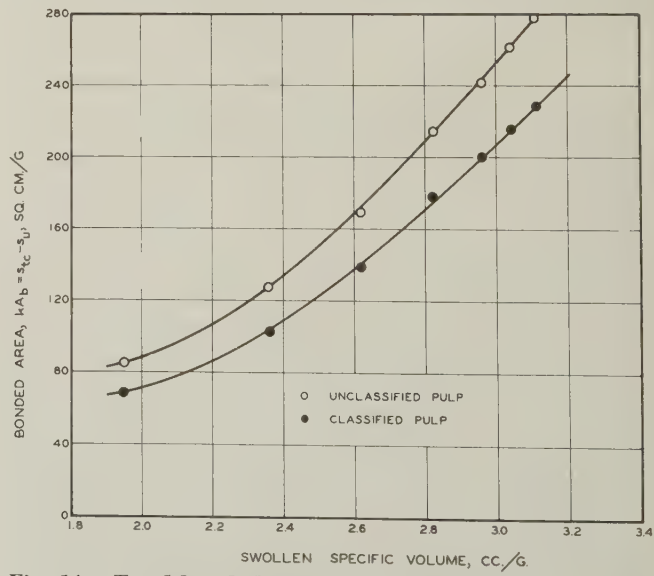

Fig. 14. Total bonded area as a function of wet swollen specific volume

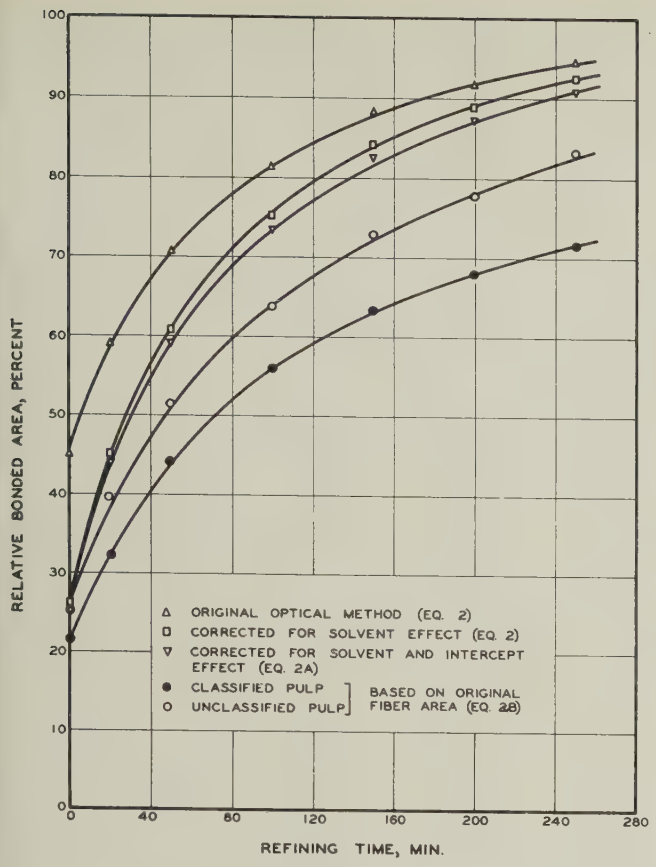
RELATIVE BONDED AREA, PERCENT
REFINING TIME, MIN.
ORIGINAL OPTICAL METHOD (EQ. 2)
CORRECTED FOR SOLVENT EFFECT (EQ. 2)
CORRECTED FOR SOLVENT AND INTERCEPT EFFECT (EQ. 2A)
CLASSIFIED PULP
UNCLASSIFIED PULP
BASED ON ORIGINAL FIBER AREA (EQ. 2B)

Fig. 15. Relative bonded area as a function of refining time

assumes that s values for solvent-dried fibers are directly proportional to the total area available for bonding and uses the simple relationship of

$$\frac{A_b}{A_t} = \frac{s_t - s_u}{s_t} \qquad (2)$$

2. Haselton's (*6*) concept of a correction factor for solvent-dried fibers to compensate for the difference in fiber shrinkage improves the accuracy of the calculation. Thus, equation (2) is used and the measured specific scattering coefficient for solvent-dried fibers, s_t, is corrected by multiplying it by the ratio of s for water-dried but unbonded fibers to s for unbeaten butanol-dried fibers.

3. A slight improvement in Haselton's correction would allow for the fact that s has a small negative value for 100% bonded area ($A_u = 0$) because of the two handsheet surfaces. In this case, $s = kA - 10$, and hence equation (2) becomes

$$\frac{A_b}{A_t} = \frac{s_t - s_u}{s_t + 10} \qquad (2a)$$

4. Data from this study and previous work by Haselton have indicated that the total dry fiber area available for effective fiber bonding, A_{tc} does not vary with refining, but may be characterized for a given unbeaten pulp by determining an extrapolated s value at zero tensile strength. This value of s_t remains constant and is designated by s_{tc}. Relative bonded area is calculated by

$$\frac{A_b}{A_{tc}} = \frac{s_{tc} - s_u}{s_{tc} + 10} \qquad (2b)$$

The four methods for estimating relative bonded area are shown in Fig. 15 for classified and unclassified pulps [only method (4) is illustrated for classified pulp for clarity]. All four calculations show the same tendency for the rate of development of relative bonded area to decrease with increasing refining time. Each improvement of the estimate of relative bonded area generally lowers the level of the degree of bonding, and the most accurate of the estimates, based on the concept of constant dry fiber area, gives relative bonded areas about 20% lower than the original optical method, over the range of beating intervals shown.

The relative bonded area curve, based on the total dry fiber area remaining constant, can be regarded as having exactly the same shape as the total bonded area curve, since relative bonded area multiplied by a constant will equal the total bonded area. It has been demonstrated that at the same total bonded area, classified and unclassified pulps have the same strength properties, and it is believed that this method of calculation gives a much more useful and reliable estimate of the extent of fiber bonding than do any of the techniques based on scattering coefficient values for butanol-dried fibers. Also, the level of relative bonded areas appears to be in a more realistic range than do the higher values obtained with butanol-dried fibers.

Total Bonded Area

The calculation of an absolute value for total bonded area requires that the constant, k, in equation (1) be known. The relationship, $s = kA - 10$, established by Haselton (*6*) for bleached spruce sulphite fibers was shown in Fig. 1. It would be expected that this correlation would hold for the similar bleached sulphite fibers of this study. A value for the dry area may be estimated in the following manner.

For the classified, unbeaten pulp, microscopic, silvering, and filtration techniques all gave essentially the same value of 7600 sq. cm. per g. external surface area of the fibers in the water-swollen state. Microscopic measurement of equivalent fiber widths for the same pulp in the wet and dry states of 35.8 and 32.3 mu, respectively, may be used to estimate the effect of shrinkage on specific surface by assuming the surface area to be directly proportional to the equivalent fiber width. Thus, the dry external area is estimated to be (7600) (32.3/35.8) or 6850 sq. cm. per g. The corresponding s value for these fibers is 309 sq. cm. per g. from Fig. 5, and these s and A values fall exactly on Haselton's correlation in Fig. 1. Since the estimated area includes only external area, it appears that the lumen of the water-dried fibers may be completely bonded and its surface unavailable for light scattering. Therefore, Haselton's correlation would give an accurate value for true external bonded fiber area.

A logical question which arises is whether Haselton's correlation will hold for fibers other than bleached spruce sulphite. As mentioned previously, specific scattering coefficient depends upon the size and shape of the particles and upon the indices of refraction of the particles and the surrounding medium. If Haselton's correlation between specific scattering coefficient and fiber area holds for all types of fibers, then the effect of difference in fiber shape and index of refraction would have to be negligible. If differences are found, it might be expected that three extremes in fiber shape would be represented by softwoods, hardwoods containing ves-

sel segments, and irregularly shaped groundwood with little fiber identity. Since lignin has a different index of refraction than cellulose, the correlation may also be affected by the degree of fiber delignification. It may also be possible that highly lignified fibers will be stiff enough to prevent bonding of the lumen when the fibers are dried from water, and, hence, some internal area may scatter light. These effects are under investigation in gas adsorption studies, but it is not presently known if their influence on specific scattering coefficient is of sufficient magnitude to affect the correlation between specific scattering coefficient and area shown in Fig. 1.

The establishment of one or several correlations between specific scattering coefficient and fiber specific surface may have great utility in the determination of fiber specific surface since the presently available methods are generally tedious and time-consuming. The specific scattering coefficient for dry but unbonded fibers is easily determined by measuring specific scattering coefficient and tensile strength for unbeaten handsheets at several moderate values of wet pressure, and then extrapolating to zero tensile strength for the desired s value. The slope of the s versus tensile strength curve is very small at low wet pressure and thus the extrapolation may be made with good precision. Knowledge of the extrapolated s value and use of an s versus A correlation will give the total dry fiber specific surface. Additional measurements of fiber swelling may be used to translate this area to a wet fiber specific surface. Once the extrapolated s value is determined for a pulp, the measurement of specific scattering coefficient of handsheets at any beating interval will permit calculation of a number proportional to total bonded area (kA_b) or relative bonded area (A_b/A_{tc}) at these beating intervals. Again, knowledge of k will permit calculation of the absolute values of bonded area. Finally, interpretation of strength development in paper as a function of bonded area will provide a more rational basis for pulp evaluation and may provide more insight into the possible effects of other factors such as fiber length, fiber strength, bonding strength, formation, etc.

Effect of the Wavelength of Light

The specific scattering coefficient data which were obtained at wavelengths of 450 and 550 mmu were determined only for handsheets of standard wet-pressing intervals, and thus a comparison of relative bonded areas to values at 650 mmu may be made only with use of equation (2) representing the original optical technique. The comparison between relative bonded area calculated from the specific scattering coefficients at the three different wavelengths is given in Table II. It can be seen that there is a slight tendency for relative bonded area values to decrease with increasing wavelength, but the difference between the three sets of values is relatively small. Therefore, although the level of scattering coefficient depends upon the wavelength of light, the ratio of s values is about the same, indicating the validity of the assumption of a linear relationship between specific scattering coefficient and area ($s = kA$) and that the relationship is affected only by the value of the constant, k.

As previously noted, one of the weak points in the use of the optical technique to evaluate relative bonded area is the possibility of areas in optical contact (involving distances of separation of a small fraction of the wavelength of the incident light) being greater than the actual bonded area (involving separation of surfaces of only several Angstrom units). If the area in optical contact is significantly greater than the fiber bonded area, then it would be expected that increasing the wavelength of light would give larger values of relative bonded area. The very slight trend shown by the data in Table II is opposite to this, and therefore the results imply that the area in optical contact is not significantly different than the actual fiber bonded area.

Table II. Scattering Coefficients of Butanol and Standard Handsheets at Different Wavelengths

	Relative bonded area,[a] %					
	Unclassified pulp			*Classified pulp*		
Wavelength, mmu →	*450*	*550*	*650*	*450*	*550*	*650*
	46.1	45.4	43.6	41.9	41.3	40.3
	62.9	62.2	61.3	53.7	53.9	53.3
	73.7	70.6	69.9	64.6	63.0	63.1
	81.3	80.6	80.0	76.1	74.9	74.5
	90.0	89.3	89.2	79.9	79.0	78.5
	92.9	92.7	92.6	84.8	83.9	83.6
	93.8	93.5	93.4	87.7	86.8	86.9

[a] Calculation based on regular optical technique, equation (2).

SUMMARY

An optical technique was used to measure specific scattering coefficients of handsheets, and the data were utilized in estimates of relative bonded area. By correlating tensile strength with the bonded area indicated from the scattering coefficient data, it appeared that the total dry area available for fiber bonding, which is effective in developing tensile strength, remains *constant* with refining time, and is unaffected by the production of fines or the degree of fibrillation. When solvent-drying is used to prepare unbonded handsheets to estimate the total area available for fiber bonding, spuriously high values of relative bonded area are obtained for the following reasons:

1. Solvent-dried fibers undergo relatively little shrinkage and therefore the swollen external area and lumen area contribute to light scattering.

2. When beaten, a part of the exposed fibrils contribute to light scattering. These fibrils do not represent the full extent of external fibrillation as measured by a filtration technique, but rather correspond very roughly to the surface area measured in the silvering method.

In estimating the total area available for fiber bonding, the area required is the total *dry* fiber area. Apparently, this area is lower than indicated for solvent-dried fibers because of fiber shrinkage, bonding of fibrils to parent fibers, and bonding of part of the lumen surface. A further complication for solvent-dried fibers is caused by the presence of a variable amount of fines in whole pulps, some of which are lost in forming solvent-dried handsheets. The fines affect the specific scattering coefficient but do not contribute to the effective bonded area.

It is recommended that solvent-dried handsheets should not be used to estimate relative bonded area. The best present method for determining the total dry fiber area available for bonding consists of extrapolating the specific scattering coefficient and tensile strength relationship for an unbeaten pulp at relatively low degrees of wet-pressing to zero tensile strength. The as-

sumption is made that the specific scattering coefficient s, is proportional to fiber specific surface, and the difference between the extrapolated s value and subsequent s values for water-dried handsheets is taken as proportional to the effective bonded area. This difference, divided by the extrapolated s value, is the relative bonded area which is effective in developing tensile and other related strength properties.

Numbers proportional to the total bonded area were calculated in this manner, and correlated with the strength properties of two series of pulps, unclassified (whole pulp) and classified (fines removed) at various degrees of refining in a ball mill. The strength of the unclassified pulps was greater than that of classified pulps at a given refining interval, but tensile (including z-tensile) strength, tearing strength, folding strength, and apparent density were the same for both pulps at the same total bonded area. The correlations supported the proposed method of calculating bonded area since other factors influencing strength, such as fiber length, fiber strength, formation, and bonding strength, were essentially constant for the pulps used in this study. It is proposed that the only role of fibrillation and fines in producing sheet strength is to provide greater surface tension forces during drying. The potential dry fiber area available for bonding is the original dry unbeaten fiber surface, irrespective of degree of refining.

In comparing the specific scattering coefficient and external area of the water-dried, unbeaten fibers to the linear correlation of scattering coefficient and fiber area established by Haselton (*6*), it appeared that most, if not all, of the lumen surfaces were bonded during drying. This fact would indicate the possible utility of using measurements of specific scattering coefficient to characterize external fiber specific surface, and using Haselton-type correlations to translate relative bonded area to absolute values of externally bonded fiber surfaces.

Specific scattering coefficients determined at different wavelengths from 450 to 650 mmu, gave essentially the same values for relative bonded area of handsheets. This fact supports the assumption of a linear relationship between specific scattering coefficient and fiber area, and also implies that areas in optical contact may not be significantly different from actual bonded fiber surfaces. The general validity of the optical technique for estimating relative bonded area is supported by the findings of this study, and the relative ease and utility of using bonded area to correlate strength development in pulps is emphasized.

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The authors wish to thank the 37 pulp and paper manufacturing companies cooperating in the Pulp Evaluation Group for permission to publish these results. The assistance and helpful criticism of L. R. Dearth, J. W. Swanson, and J. A. Van den Akker are gratefully acknowledged.

The Microbial Oxidation of Cellobiose, Butyric and Lactic Acids in the Presence of Calcium Lignosulphonate

WALTER A. LAWRANCE and WILLIAM SAKAMOTO

Calcium lignosulphonate obtained from sulphite spent liquor has been found to be relatively stable to microbial oxidation in water from a river which has been receiving pulp and paper mill wastes for over 60 years. This report contains the results of biological oxygen demands obtained with certain cellulose degradation products, cellobiose, butyric and lactic acids and their calcium salts, alone and in the presence of calcium lignosulphonate. With the river organisms the microbial rate of oxidation of cellobiose was unaffected by the presence of calcium lignosulphonate whereas the B.O.D.'s of the acids and their salts were somewhat lower. This investigation is a continuation of that reported in *Tappi* 40: 342–347 (1957).

Walter A. Lawrance and William Sakamoto, Bates College, Hedge Laboratory, Lewiston, Me.

THE manufacture of pulp and paper usually results in the discharge of waste products to a nearby stream. Some materials such as cellulose are carried in suspension while others, sugars, lignosulphonates, etc., are in solution. A portion of the cellulose may be colloidally dispersed but fibers eventually will settle to the bed of the river and slowly decompose under anaerobic conditions. In the presence of ample dissolved oxygen, finely dispersed cellulose may undergo relatively rapid microbial hydrolysis and oxidation.

The degradation of cellulose can be accomplished by microorganisms in diverse ways. Hydrolases produce cellobiose and then glucose which may be aerobi-

cally oxidized to carbon dioxide and water. Anaerobic degradation which occurs in sludge beds is more complex and results in the formation, among other compounds, of fatty and lactic acids. With certain conditions the calcium salts of the acids may be present. These acids by diffusion or otherwise reach the overlying water where they are subsequently oxidized.

One of the objectives of this investigation was to determine whether microbial oxidation of some of the degradation products of cellulose, cellobiose, butyric and lactic acids and their calcium salts, is affected by the presence of calcium lignosulphonate. Also, do these compounds influence any biological oxidation of lignosulphonates.

In an earlier report (*1*) the microbial oxidation of lignin* alone and in the presence of certain pure carbohydrates was stated to be very small. With the exception of xylose the 5-day B.O.D.'s of the sugars were usually unaffected by the presence of lignin. The results of this second investigation indicate that bacterial oxidation of lignin is unaffected by the cellulose degradation products but the B.O.D.'s of the acids and their calcium salts were lower when lignin was present.

CALCIUM LIGNOSULPHONATE

The lignin used in all of the experiments was taken from the same sample as that employed in the previous investigation. The B.O.D.'s were small and very similar to those reported earlier. They may be due to impurities in the sample or to the oxidation of a portion of the lignin (*2*). Determinations made in stabilized Androscoggin River water—this river has received sulphite spent liquor for over 50 years—indicate that the amount of lignin oxidized (tyrosine test) during a period of 20 days at 20°C. varied from 6 to 7%. Longer incubations did not materially change these percentages. No significant changes were observed in the pH of the solutions during the test periods. These data are illustrated in Figs. 1 to 6, inclusive.

Table I. Calcium Lignosulphonate, 60 p.p.m.

Days	*Dilution*	*B.O.D. p.p.m.*
2	1:1	2.44
5	1:4	2.60
7	1:7	4.63
10	1:7	6.15
20	1:9	8.10

* The term lignin when used in this report refers to calcium lignosulphonate unless otherwise indicated.

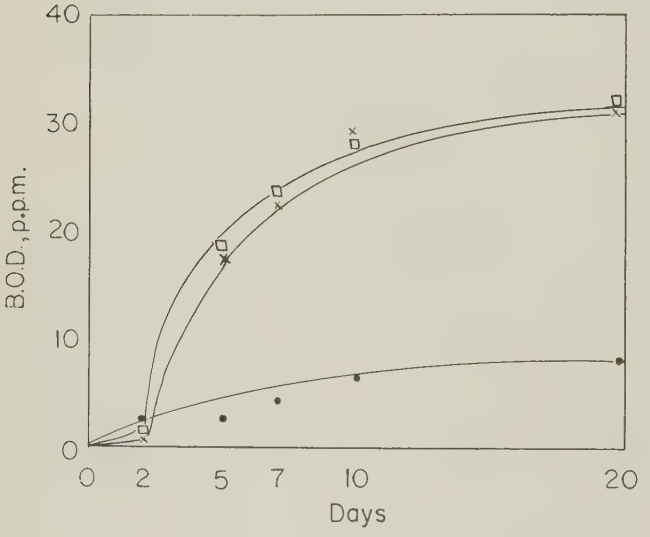

Fig. 1

Cellobiose, □. Cellobiose and lignin, ×. Lignin, ●.

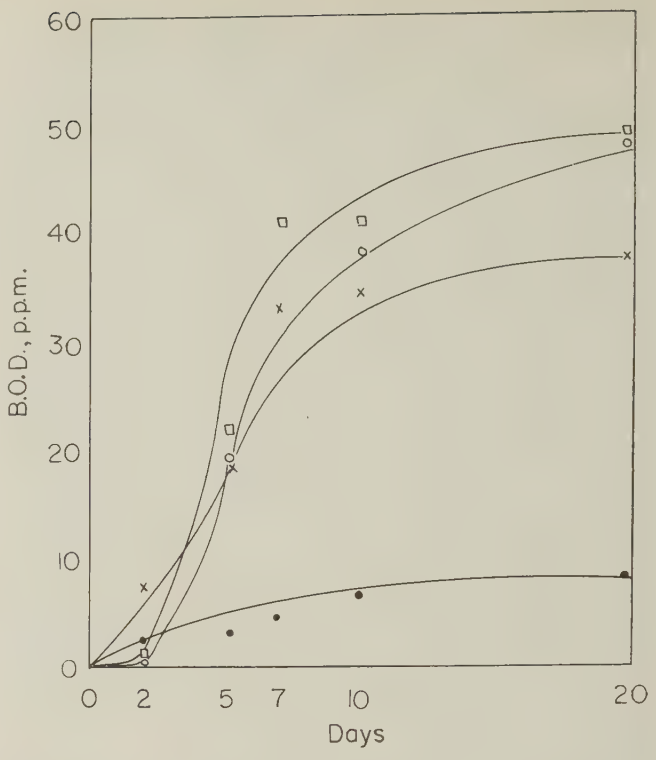

Fig. 2

Butyric acid, □. Butyric acid and lignin, 60 p.p.m., ×. Butyric acid and lignin, 120 p.p.m., ○. Lignin, ●.

CELLOBIOSE

The disaccharose, cellobiose, may be considered as the principal unit in the cellulose molecule. The enzyme, cellulase, present in certain water-borne microorganisms, hydrolyzes cellulose to cellobiose which is hydrolyzed by cellobiase to glucose.

Table II

Days	*Dilution*	*Cellobiose, 60 p.p.m., pH 6.5 B.O.D. p.p.m.*	*Cellobiose, 60 p.p.m.; lignin, 120 p.p.m. B.O.D. p.p.m.*
2	1:1	2.24	1.36
5	1:4	19.2	17.9
7	1:7	23.9	23.3
10	1:7	28.3	29.3
20	1:9	32.0	31.0

Cellobiose (C.P. grade), was incubated at 20°C., pH 6.5, alone and mixed with lignin. Stock solutions contained 60 p.p.m. cellobiose and 60 p.p.m. cellobiose with 120 p.p.m. lignin.

The lignin had very little influence on the rate of the B.O.D.

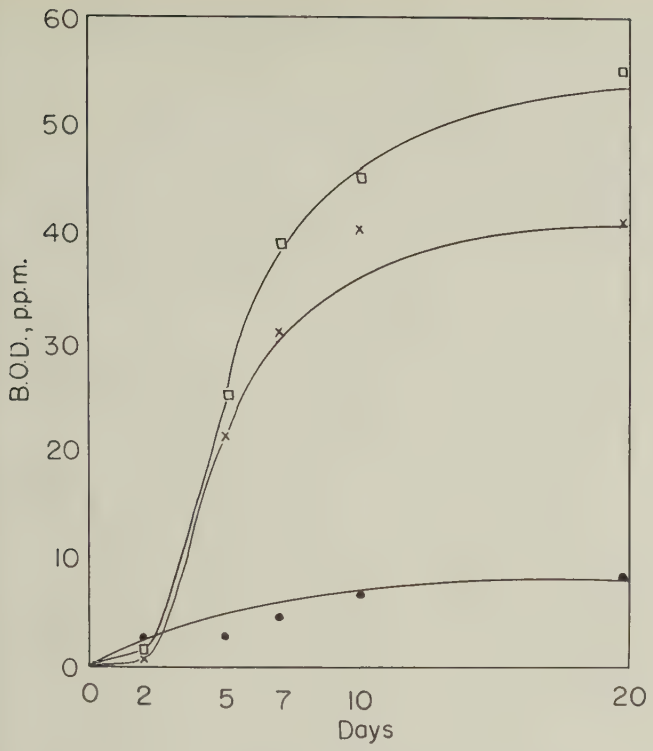

Fig. 3. pH 5.1

Calcium butyrate, □. Calcium butyrate and lignin, ×. Lignin, ●.

The anaerobic conversion of cellulose to acids, alcohols, and gas in sludge is a very slow process. Hydrolysis to cellobiose and glucose may be inferred but most of the subsequent reactions are not known or imperfectly understood. Glucose may be oxidized or fermented into other compounds. With anaerobic bacteria these products include the odoriferous butyric and lactic acids. For some time the senior author has observed conditions which seem to indicate that the biological oxidation of these acids in river water may be retarded by the presence of lignosulphonates. The results of this investigation provide evidence that supports the deduction that the presence of lignin lowers the B.O.D. of butyric and lactic acids.

BUTYRIC ACID

Several determinations were made with butyric acid alone and with different concentrations of lignin. The stock solution of butyric acid was 100 p.p.m. Incubations were made at 20°C. with 0, 60, and 120 p.p.m. lignin, respectively, for a period of 20 days. pH was adjusted to 6.0 p.p.m. with dilute sodium hydroxide. The analytical data are recorded in Tables III and IV and illustrated in Fig. 2.

Table III

Days	*Dilution*	*Butyric acid, 100 p.p.m. B.O.D. p.p.m.*	*Butyric acid, 100 p.p.m.; lignin, 60 p.p.m. B.O.D. p.p.m.*
2	1:1	1.06	7.54
5	1:4	22.0	18.7
7	1:8	41.7	32.9
10	1:8	41.7	34.4
20	1:10	49.2	37.4

Table IV. Comparison of Lignin Concentration

Days	*Butyric acid, 100 p.p.m.; lignin, 60 p.p.m. B.O.D. p.p.m.*	*Butyric acid, 100 p.p.m.; lignin, 120 p.p.m. B.O.D. p.p.m.*
2	7.54	0.64
5	18.7	19.2
7	32.9	...
10	34.4	38.9
20	37.4	48.3

The data indicate a definite retarding effect of the lignin upon the B.O.D. of butyric acid and when allowance is made for B.O.D. contributed by the lignin the difference is more evident.

CALCIUM BUTYRATE

Solutions containing calcium butyrate and calcium butyrate mixed with lignin, 120 p.p.m. for each component, were incubated at 20°C. for periods up to 20 days. To determine the influence of hydrogen ion concentration one series was adjusted to pH 5.1 with dilute butyric acid, the other series was unadjusted

Table V

Days	*Dilution*	*Calcium butyrate, 120 p.p.m. B.O.D. p.p.m. pH 5.1*	*Calcium butyrate, 120 p.p.m. B.O.D. p.p.m. pH 7.6*	*Calcium butyrate, 120 p.p.m.; lignin, 120 p.p.m. B.O.D., p.p.m. pH 5.1*	*Calcium butyrate, 120 p.p.m.; lignin, 120 p.p.m. B.O.D. p.p.m. pH 7.6*
2	1:1	1.48	0.06	1.12	1.13
5	1:4	25.3	13.0	21.7	12.5
7	1:7	39.3	35.4	30.6	17.4
10	1:7	45.1	40.9	40.4	20.2
20	1:9	55.3	50.9	41.0	27.0

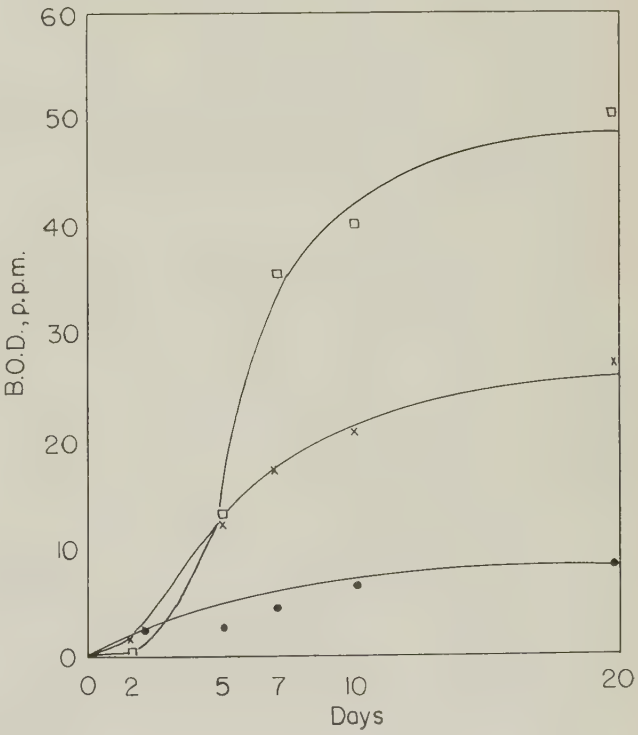

Fig. 4. pH 7.6

Calcium butyrate, □. Calcium butyrate and lignin, ×. Lignin, ●.

Table VI

Days	Calcium butyrate, 120 p.p.m., pH 7.6 Dilution	B.O.D. p.p.m.	Calcium butyrate, 120 p.p.m.; lignin, 120 p.p.m. Dilution	B.O.D. p.p.m.
2	1:3	0.25	1:3	0.35
5	1:5	26.2	1:5	18.4
10	1:39	30.8	1:8	29.3
20	1:39	52.8	1:14	36.1

at pH 7.6. The presence of lignin at pH 5.1 retarded the rate of microbial oxidation but the effect was much greater in the weak alkaline range (see Figs. 3 and 4).

When the dilution ratios were increased in the pH 7.6 series, the 5-day B.O.D.'s were larger but the 20-day demands were not appreciably increased.

LACTIC ACID

The lactic acid stock solution contained 100 p.p.m. and the pH was adjusted to 5.1 with dilute sodium hydroxide. Another solution was prepared with lactic acid 100 p.p.m. and lignin 60 p.p.m.; the pH was adjusted to 5.1.

Table VII

Days	Dilution	Lactic acid, 100 p.p.m. B.O.D. p.p.m.	Lactic acid, 100 p.p.m.; lignin, 60 p.p.m. B.O.D. p.p.m.
2	1:1	3.34	1.41
5	1:4	17.9	15.9
7	1:7	26.3	...
10	1:7	28.7	17.8
20	1:9	35.7	24.1

Microbial oxidation of lactic acid was retarded by the lignin and in some of the runs the results obtained were very erratic.

CALCIUM LACTATE

The B.O.D. of calcium lactate was considerably lower when it was incubated in the presence of lignin sulphonates. The stock solutions contained 120 p.p.m. and the pH was 6.3.

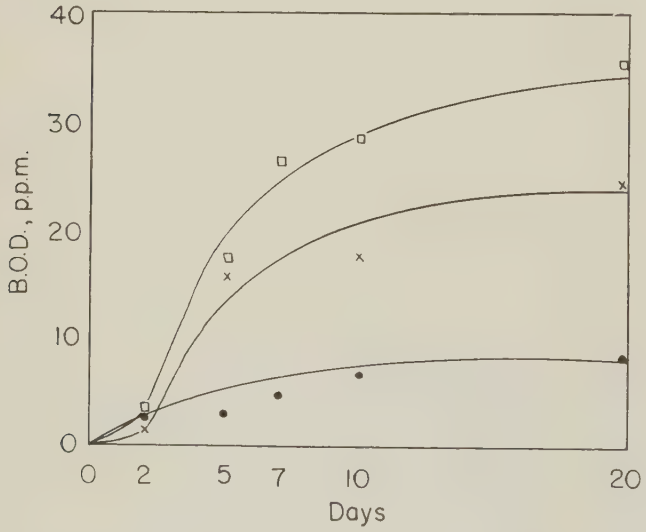

Fig. 5

Lactic acid, □. Lactic acid and lignin, ×. Lignin, ●.

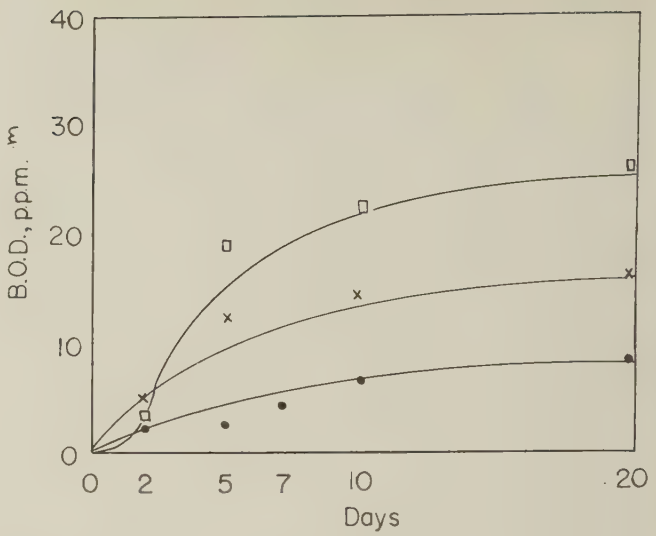

Fig. 6

Calcium lactate, □. Calcium lactate and lignin, ×. Lignin, ●.

Table VIII

Days	Dilution	Calcium lactate, 120 p.p.m. B.O.D. p.p.m.	Calcium lactate, 120 p.p.m.; lignin, 120 p.p.m. B.O.D. p.p.m.
2	1:1	3.18	5.00
5	1:5	19.8	12.9
10	1:5	22.7	14.8
20	1:7	26.3	16.2

CONCLUSIONS

1. Calcium lignosulphonate did not produce an appreciable change in the B.O.D. of cellobiose solutions.
2. Butyric and lactic acids and their calcium salts had smaller B.O.D.'s when lignosulphonates were present.
3. The B.O.D. of calcium butyrate-lignin solutions was much smaller at pH 7.6 than 5.1.

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APPENDIX

Carbohydrate: The cellobiose was the purest available and precautions were taken to avoid contamination.

Calcium lignosulphonate: The material used was taken from the same bottle as that used for the investigation described in an earlier paper.

Incubation media: Sterilized aerated distilled water was fortified with

Ammonia sulphate.....2.5 p.p.m.
Calcium phosphate.....0.01 p.p.m.
Potassium dihydrogen phosphate.....0.5 p.p.m.
Magnesium sulphate....0.01 p.p.m.

Seedings were made by adding three ml. of Androscoggin River water to each B.O.D. bottle. All incubations were conducted at 20°C.

Incubation periods: The periods chosen were usually 2, 5, 7, 10, and 20 days.

Analyses: Analyses were made by standard methods procedure. The hypochlorite method was used for all dissolved oxygen determinations.

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ASSOCIATION NEWS AND EVENTS

National Conferences

Forty-Fourth Annual Meeting, Commodore Hotel, New York, N. Y., Feb. 23–26, 1959.

Tenth Coating Conference, Statler Hotel, Boston, Mass., May 25–27, 1959.

Tenth Testing Conference, Multnomah Hotel, Portland, Ore., Aug. 17–21, 1959.

Fundamental Research-Wet Strength Conference, I.P.C., Appleton, Wis., Sept. 9–11, 1959.

Ninth Corrugated Containers Conference, Jung Hotel, New Orleans, La., Sept. 15–17, 1959.

Fourteenth Paper-Plastics Conference, Edgewater Beach Hotel, Chicago, Ill., Sept. 21–23, 1959.

Fourteenth Engineering Conference, Penn-Sheraton Hotel, Pittsburgh, Pa., Oct. 12–15, 1959.

Thirteenth Alkaline Pulping Conference, Robert Meyer Hotel, Jacksonville, Fla., Nov. 4–6, 1959.

Local Section Meetings

Pacific: Camas, Wash., April 7, 1959, "Shibley Award Meeting"; Gearhart, Ore., May 21–23, 1959, "Multiple Water Use." Joint TAPPI-Superintendents annual meeting.

Golden Gate District (*Pacific Section*): Jan. 27, 1959; March 24, 1959; May 5, 1959.

Kalamazoo Valley: Inman's Restaurant, Galesburg, Mich., March 19, 1959, "Printability of Paper and Paperboard"; Inman's Restaurant, Galesburg, Mich., April 23, 1959; Hotel Harris, Kalamazoo, Mich., May 14, 1959, Recognition Night for Western Michigan University award winners.

Chicago (Chicago Bar Association, 29 So. LaSalle St., Chicago, Ill.): Feb. 3, 1959; March 3, 1959; April 7, 1959; May 5, 1959.

St. Louis District (*Chicago Section*) Le Chateau Restaurant, 10405 Clayton Road, St. Louis (all meetings): "Nondestructive Testing of Paper," by Arthur C. Dreschfield, Chicago Testing Laboratories, Chicago, Ill., April 16, 1959.

Maine-New Hampshire: Samoset Hotel, Rockland, Me., June 12–13, 1959.

New England: Roger Smith Hotel, Holyoke, Mass., April 10, 1959; June, 1959. Place and date to be determined.

Eastern District (*New England Section*): Greater Boston Area, March 9, 1959; June 1959, annual meeting with New England Section.

Southeastern: Francis Marion Hotel, Charleston, S. C., March 20, 1959; Jekyll Island Hotel, Jekyll Island, Ga. May 8, 1959.

Gulf Coast District (*Southeastern Section*): Mobile, Ala., March 13, 1959; New Orleans, La., May 15, 1959.

Virginia-Carolina: Thomas Jefferson Hotel, Richmond, Va., March 20, 1959; Franklin, Va., May 15, 1959. Visit to mill of Union Bag-Camp Paper Corp.

Lake Erie: Carter Hotel, Feb. 20, 1959, "Advantages and Disadvantages of Each Type of Printing Process"; Carter Hotel, April 17, 1959, "Characteristics of Clupak Paper, What Is It? What Is Its Future?"

Papermakers and Associates of Southern California: Los Angeles, Calif., March 19, 1959; May 21, 1959.

Lake States: Kaukauna, Wis., March 10, 1959, "Water Removal on Paper Machines"; Appleton, Wis., April 14, 1959, "Engineering"; Menasha, Wis., May 12, 1959, C. J. West Award Meeting.

Delaware Valley (all meetings held at Engineers Club, Philadelphia, Pa.): March 26, 1959; April 23, 1959; May 22, 1959.

Ohio: Manchester Hotel, Middletown, Ohio, Feb. 10, 1959; Chillicothe Elks Club, Chillicothe, Ohio, March 12, 1959; visit to mill of Chillicothe Paper Co. to see new paper machine; American Legion Hall, Middletown, Ohio, April 14, 1959; Hartwell Reaction Center, Cincinnati, Ohio, May 14, 1959, Annual Meeting.

Indiana District (*Ohio Section*) (meetings at the Hunt Room, Marott Hotel, Indianapolis, Ind.): Feb. 17, 1959; March 17, 1959; April 23, 1959; May 19, 1959; and June 16, 1959.

Empire State: Whiteface Inn, Whiteface, N. Y., June 11–14, 1959. Annual meeting.

Empire State (*Central District*) (all meetings to be held at the University Club, 431 East Fayette St., Syracuse, N. Y.): Feb. 6, 1959; March 6, 1959; April 3, 1959, visit to mill of Armstrong Cork Co., Fulton, N. Y. Dinner meeting at Fulton Chamber of Commerce; May 1, 1959, "Senior Night," NYSCF; May 21, 1959, annual meeting of Fulton C. of C., Fulton, N. Y.

Empire State (*Metropolitan District*) (all meetings to be held at 465 Lexington Ave., New York, N. Y.): March 10, 1959, "Coating Methods"; April 14, 1959, "Development in the Printing Industry"; May 12, 1959; Annual Meeting.

Empire State (*Northern District*) (all meetings to be held at Woodruff Hotel, Watertown, N. Y.): "Corrosion in Action," by International Nickel Co., Feb., 12, 1959; "Corrosion Measurements," March 12, 1959; Northern District Awards Program, April 9, 1959; Annual Meeting, May 14, 1959.

Empire State (*Eastern District*) (all meetings to be held at Queensbury Hotel, Glens Falls, N. Y.): "Synthetics in Felts," Feb. 19, 1959; Junior Awards Night, March 19, 1959; Ladies' Night, April 18, 1959; Annual Symposium, subject to be announced, May 21, 1959.

Empire State (*Western District*) (all meetings at the Prospect House, Niagara Falls, N. Y., unless otherwise indicated): "Paper Machine Maintenance," speaker to be announced, Feb. 4, 1959; Joint Meeting with Niagara Branch of C.P.P.A. Technical Section, March 11, 1959; Annual Ladies' Night—April; Field Trip—May (Details to be announced later).

Other 1959 Conferences

Jan. 28–30	CPPA Annual Meeting, Queen Elizabeth Hotel, Montreal, P. Q.
June 17–20	CPPA Summer Meeting, Manor Richelieu Hotel, Murray Bay, P. Q.
Sept. 13–18	Am. Chem. Society, Atlantic City, N. J.
Oct. 11–16	ASTM, San Francisco, Calif.
Oct. 26–28	Packaging Institute, Statler Hotel, New York, N. Y.
Nov. 9–11	National Paperboard Assoc., New York, N. Y.

MIT

The MIT Alumni Luncheon will be held in the Hotel Biltmore, Room 135, at 12 noon, Wednesday, Feb. 25, 1959.

Annual Meeting Personnel Service

To assist companies recruiting technical men by publicizing their personnel needs, a new service will be inaugurated at the 1959 TAPPI Annual Meeting in New York. A "Personnel Service" room will be provided at the Hotel Commodore, so that company members of the Association can post brief

descriptions of their openings in a single location available to all delegates. This service will be offered only to TAPPI's corporate and sustaining members.

Companies wishing to participate are asked to forward brief position descriptions to the Association office by Feb. 15, 1959. These descriptions will be displayed on bulletin boards in the "Personnel Service" room on Monday through Wednesday, February 23–25, from 9 a.m. to 4 p.m. These descriptions should include the name and address of a company representative who may be approached if additional information or an interview is desired. Companies planning to have a personnel representative at the Annual Meeting may add his name and hotel room number to the descriptions after he has arrived in New York. If the position descriptions of any one company cover more than a single sheet, the subsequent pages will be posted behind the first sheet on the bulletin boards.

The Association's role in this activity is expressly limited to providing the area to its company members without charge, supplying an attendant, and publicizing the location of the room in the program booklet and on the conference bulletin boards.

Chemical Engineering Committee

A notable first at the 1959 TAPPI Annual Meeting will be the technical session on "Systems Engineering and Operations Research," sponsored by the TAPPI Chemical Engineering Committee according to A. W. Plummer, Kimberly-Clark Corp., Neenah, Wis., chairman of the committee. The results of two experimental investigations on papermaking problems in these areas will be reported. C. W. Carroll, The Institute of Paper Chemistry, is to discuss "An Operations Research Approach to the Economic Balance in a Kraft Pulping Operation," and L. W. Zabel, Kimberly-Clark Corp., Neenah, Wis., will present findings on "The Application of an Analog Computer to a Paper Manufacturing Problem."

Mr. Carroll has made an exhaustive study of the material and energy flows in a realistic (but hypothetical) kraft cycle, including digestion, stock washing, evaporation, recovery, and causticization. For a specified range of pulping conditions, he has derived a mathematical expression relating active alkali, liquor-to-wood ratio, time of cook, yield, and permanganate number and has confirmed this by pilot plant scale cooks. By assigning appropriate cost figures to the material and energy relationships, Mr. Carroll is able to prescribe design and operating conditions for maximum "profitability" of the unit. Included in his contribution is a novel method of mathematically analyzing the data and programming it for solution on an IBM 650 Automatic Digital Computer.

Mr. Zabel has attacked the vexing problem of determining the machine direction temperature profile on the surface of a Yankee drier by simulating the drier system on a PACE Analog Computer. From a knowledge of the thermal conductivity of the drier metal, the temperature of the high-pressure steam in the drier, and the basis weight, temperature, and moisture content of the sheet going on the drum, Mr. Zabel set up a system of 25 simultaneous equations for determining roll temperature as a function of distance of sheet contact. These were rapidly evaluated by the analog computer. Interesting variations in the temperature profile in going from cast iron to bronze drums and in changing from cold to preheated sheets were observed.

Prior to the presentation of the above experimental papers, E. F. Thode, The Institute of Paper Chemistry, who is chairman of the Chemical Engineering Committee's Subcommittee on Systems Engineering and Operations Research, will present a survey paper introducing the concepts of these fields in terms of engineering applications in the pulp and paper industry. Members of the subcommittee responsible for this program and a subsequent session scheduled for the 1959 TAPPI Engineering Conference in Pittsburgh include the individuals named above and E. C. Bowen, The Bowen Corp., Cambridge, Mass., J. F. Gorham, University of Maine, Orono, Me., and J. L. McCarthy, University of Washington, Seattle, Wash.

Inter-Society Color Council

The 28th annual meeting of the Inter-Society Color Council will be held at the Statler Hilton Hotel, New York, on Wednesday, April 1, 1959.

On Tuesday, March 31, the Inter-Society Color Council will be the guests of the Interchemical Corp. at their Color Center from 7:00 to 10:00 p.m.

The annual business meeting will be held Wednesday morning, April 1. During the afternoon a symposium will be held under the general title of "The Use of Material Standards for Color Matching." The moderator will be W. J. Kiernan, program chairman for this annual meeting. The speakers are: A. J. Benjamin, Monsanto Chemical Co., who will speak on "Material Color Standards; Practical Problems and Acceptance"; Harry J. Keegan, National Bureau of Standards, who will speak on "Material Color Standards; the Instrumental Approach"; Hugh Davidson and Henry Hemmendinger of Davidson and Hemmendinger will speak on "Material Color Standards; the Visual Approach."

At the banquet on Wednesday evening the guest speaker will be Deane B. Judd, National Bureau of Standards, well-known scientist, who will speak of his personal experiences in the field of color and material color standards.

Advance registration blanks may be obtained by writing Ralph M. Evans, Secretary, Inter-Society Color Council, Color Technology Div., Building 65, Eastman Kodak Co., Rochester 4, N. Y.

Civil Engineering Committee Meetings

The Civil Engineering Committee will hold its first full committee meeting during the 44th Annual Meeting in New York in February. According to W. C. Pittam, chairman of the newly-formed committee, an organizational meeting will be held Monday afternoon, February 23. This will be followed by a luncheon meeting on Wednesday, February 25. At these two meetings the proposed scope of committee activity and possible projects will be discussed.

Men interested in participating in the activities of the Civil Engineering Committee are cordially invited to attend these meetings. Those wishing to be considered for committee membership but unable to attend the February meeting are urged to write promptly to W. C. Pittam, Stone and Webster Engineering Corp., 49 Federal St., Boston, Mass.

Paper Industry Speeches for Chemistry and Engineering Students

In talking with college undergraduates TAPPI members are frequently dismayed at how little is known about our industry's technical operations and the opportunities it can offer to technically trained men. Students on most campuses are completely unaware of the size of the paper industry, its recent growth, and its challenging problems in chemistry and engineering.

In an effort to correct this situation TAPPI has offered to provide speakers who will describe paper industry operations at meetings of the ACS, AIChE, or ASME student chapters on many college and university campuses. Within the last two months such invitations have been mailed to over 200 student chapters. The initial response to these invitations has been highly gratifying, and more that 20 student groups have scheduled paper industry programs. Speakers for these

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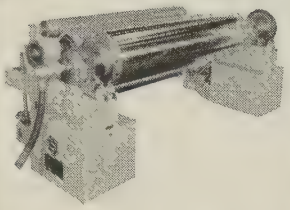

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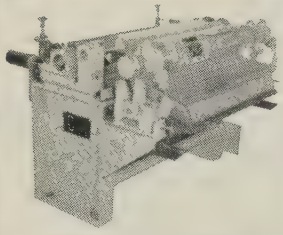

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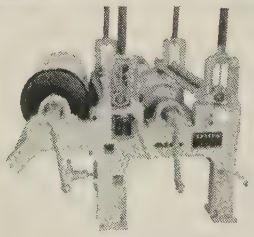

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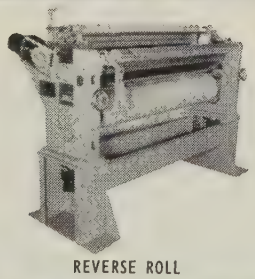

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meetings will usually be TAPPI members from the technical or operating departments of mills near the campuses.

Student meetings held in December and January include:

University of Dayton, ACS Chapter, Dec. 4, 1958. Charles S. Sweitzer, Diamond-Gardner Corp., Middletown, Ohio, was the speaker.
Lafayette College, ACS Chapter, Dec. 9, 1958. Charles S. Benz, Scott Paper Co., Chester, Pa., was the speaker.
Oregon State College, ACS Chapter, Dec. 10, 1958. Frederick C. Keeney, Weyerhaeuser Timber Co., Springfield, Ore., was the speaker.
Albright College, ACS Chapter, Dec. 10, 1958. The speaker was Philip E. Nethercut, TAPPI, New York, N. Y.
Rensselaer Polytechnic Institute, ACS-AIChE Chapters, Dec. 16, 1958. Philip E. Nethercut, TAPPI, New York, N. Y., was the speaker.
Clemson College, ASME Chapter, Dec. 18, 1958. James E. Wilkinson, Champion Paper & Fibre Co., Canton, N. C., was the speaker.
Western Reserve University, ACS Chapter, Jan. 6, 1959, James J. Higgins, Ohio Boxboard Co., Rittman, Ohio, was the speaker.
Florida State University, ACS Chapter, Jan. 7, 1959. The speaker was Lee Wakemen, Buckeye Cellulose Corp., Foley, Fla.
College of William and Mary, ACS Chapter, Jan. 12, 1959. Mr. Keith E. Bradway, Union Bag-Camp Paper Corp., Franklin, Va., was the speaker.
Wittenberg College, ACS Chapter, Jan. 13, 1959. E. W. Petrich, Howard Paper Co., Dayton, Ohio, was the speaker.
Louisiana Polytechnic Institute, ASME Chapter, Jan. 13, 1959. H. H. Mullins, Olin Mathieson Chemical Corp., West Monroe, La., was the speaker.
Bowling Green University, ACS Chapter, Jan. 21, 1959. The speaker was C. S. Sweitzer, Diamond-Gardner Corp., Middletown, Ohio.

The headquarters office has prepared kits of speech materials to assist TAPPI speakers in these presentations. These kits include paper industry statistics, directions for laboratory demonstrations of pulping and papermaking, paper industry film lists, mill tour suggestions, and selected speeches by outstanding paper industry leaders.

In addition kits of unusual paper and paperboard samples have been assembled, so that TAPPI speakers can demonstrate the versatility of paper industry products at these meetings.

Tenth Coating Conference

The Tenth TAPPI Coating Conference will be held at the Statler Hilton, Hotel, Boston, Mass., from Monday, May 25, 1959, through Wednesday, May 27, 1959.

The high light of the 1959 conference will be a panel discussion on Coatings—Past, Present, and Future by four prominent paper and board coating experts. This panel will be moderated by A. W. Neubauer of Crown Zellerbach Corp., Camas, Wash.

The following papers have been tentatively accepted by the Program Committee for presentation to the conference:

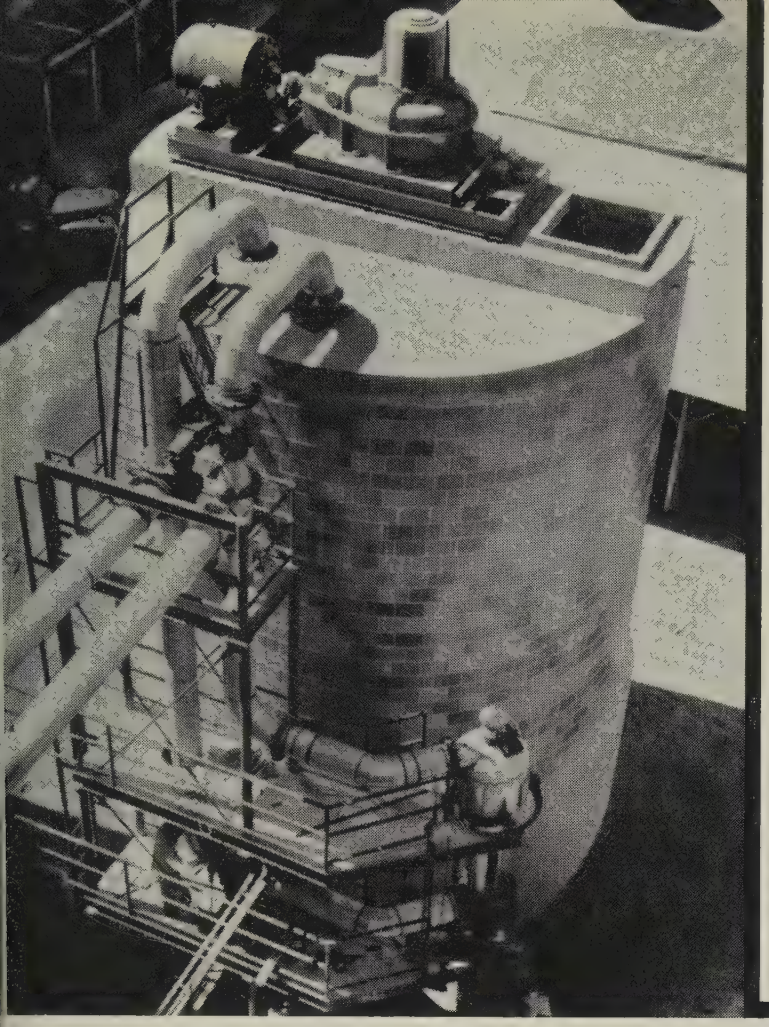
1. "The Interpretation of Statistical Data Obtained in the Coating Process," University of Maine.
2. "Comparison of the Air Doctor and Blade Coater," Dilts Division of Black-Clawson Co., Inc.
3. "Cationic Starches as Paper Coating Binders," Research & Development Laboratories, National Starch Product Inc.
4. "Study of the Water Retention of Latex-Bound Clay Coating Colors," Dow Chemical Co.
5. "The Optical Efficiency of Titanium Dioxide Pigments in Paper Coatings," Titanium Pigments Corp.
6. "The Kohler Coating Method," Abitbi Power & Paper Co., Ltd.
7. "Penetration Controlling Properties of Colloid Additives," Kelco Co.
8. "High Amylose Corn Starch, Properties and Prospects," United States Department of Agriculture.
9. "Rheological Properties of Suspension and Polymeric Solutions," University of Delaware.
10. "The Development and Testing of a Unique Polymer Binder for Coated Paper," Dewey & Almy Co.
11. "The Effect of Styrene-Butadiene Ratio on the Properties of Clay Coated Board," Koppers Co.
12. "Progress Report on TAPPI Project No. 600," J. V. Robinson, Mead Corp., Chillicothe, Ohio.

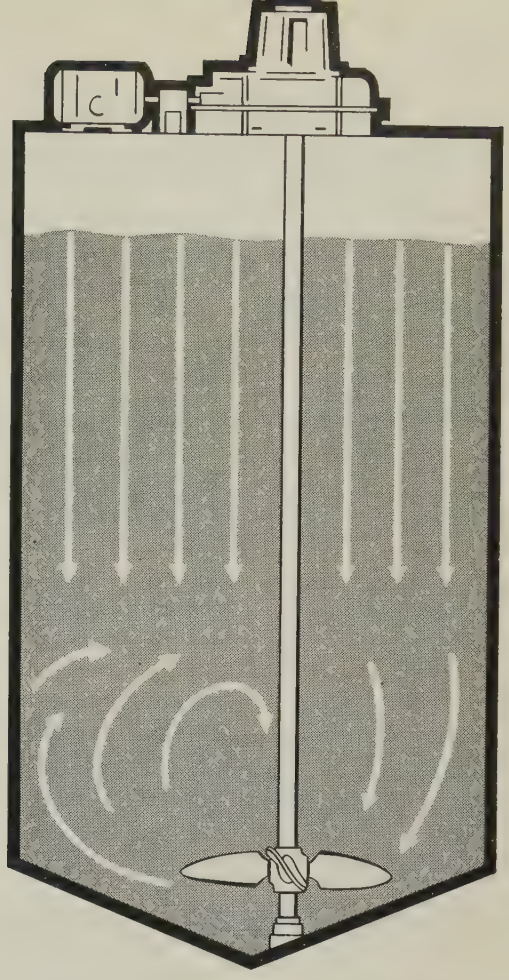
Mill visits on Tuesday afternoon, May 26, 1959, have been scheduled to Champion-International Div. of Oxford Paper Co., Lawrence, Mass.; Nashua Corp., Nashua, N. H.; and Dewey and Almy, Cambridge, Mass.

All persons interested in attending the conference are asked to make their reservations direct with the Statler Hilton Hotel, Boston, Mass.

Eucepa Meetings

Eucepa, the organization composed of the pulp and paper technical societies in various European countries, has announced plans for 1959 meetings.





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The first meeting will be held on June 1–3, 1959, at Noordwijk on Sea, Holland, and will consider "Straw Pulping."

On Oct. 12–14, 1958, the second meeting will be held in Paris, France and will be devoted to "Printability of Paper."

Details concerning these meetings may be obtained from Paul Turrel, secretary, 154 Boulevard Haussmann, Paris 9, France.

Errata

"Statistical Analysis of Some Factors Influencing the Physical Testing of Pulp," *Tappi* 40: 84–91 (1957).

There are some arithmetical errors in Table IV which, when corrected, should read as follows:

Table IV. Bulk Density Adjusted to Uniform Basis Weight (42.7 lb./ream) by Means of b_a (Coded Data)

	G_1	G_2	G_3
Pulp 1			
D_1	195	228	241
D_2	139	194	192
D_3	244	266	252
D_4	284	256	238
Pulp 2			
D_1	436	477	436
D_2	430	432	472
D_3	477	443	479
D_4	554	467	418
D_5	399	403	397
Pulp 3			
D_1	289	295	264
D_2	314	372	352
D_3	434	350	416
D_4	361	317	372
D_5	271	397	312

As a consequence Table VI of the paper must also be amended to read:

Table VI. Analysis of Variance of the Basis Weight. Corrected Bulk Data of Table IV

Variability	*d.o.f.*	*Sum of squares*	*Mean squares*	F	F_c
Between days	11	4,618.11	419.83	3.55	2.15
Between groups within days	28	3,310.60	118.24	4.76	1.50
Within groups	377	9,370.29	24.855	...	..
Total	416	17,299.00			

$\sigma_0^2 = 24.855$
$\sigma_g^2 = 9.338$
$\sigma_d^2 = 10.053$

Hence,

$$\sigma^2 = 10.053/d + 9.338/dg + 24.855/dgt$$

and for the routine determinations, when $d = g = 1$ and $t = 10$

$$\sigma^2 = 19.391 + 24.855/t$$
$$\sigma = \pm 4.68 \text{ coded units}$$
$$= \pm 0.0468 \text{ cu.cm./g.} \approx 1.99\%$$

In the Mathematical Appendix the correct formulas for the degrees of freedom of Q should read: $D.F. = n(r-1) - 1$, and for $\sum_n Sr(y^2)$, $D.F. = n(r-1)$. The correct number of degrees of freedom has, however, been used throughout the paper.

Finally, in the formula for *TSS* at the bottom of column 2, page 90, the terms $-c_n$ should read instead $+b_a x_o$, where x_o is the value of x to which the data are to be corrected. The terms involved cancel out of the equation on reduction and the simplified equation for *TSS* and all calculated values are correct.

The author, T. W. Bauer, Abitibi Power & Paper Co., Ltd., is indebted to T. Handa, Sanyo Pulp Co. Ltd., Iwakuni, Japan, for drawing his attention to these matters.

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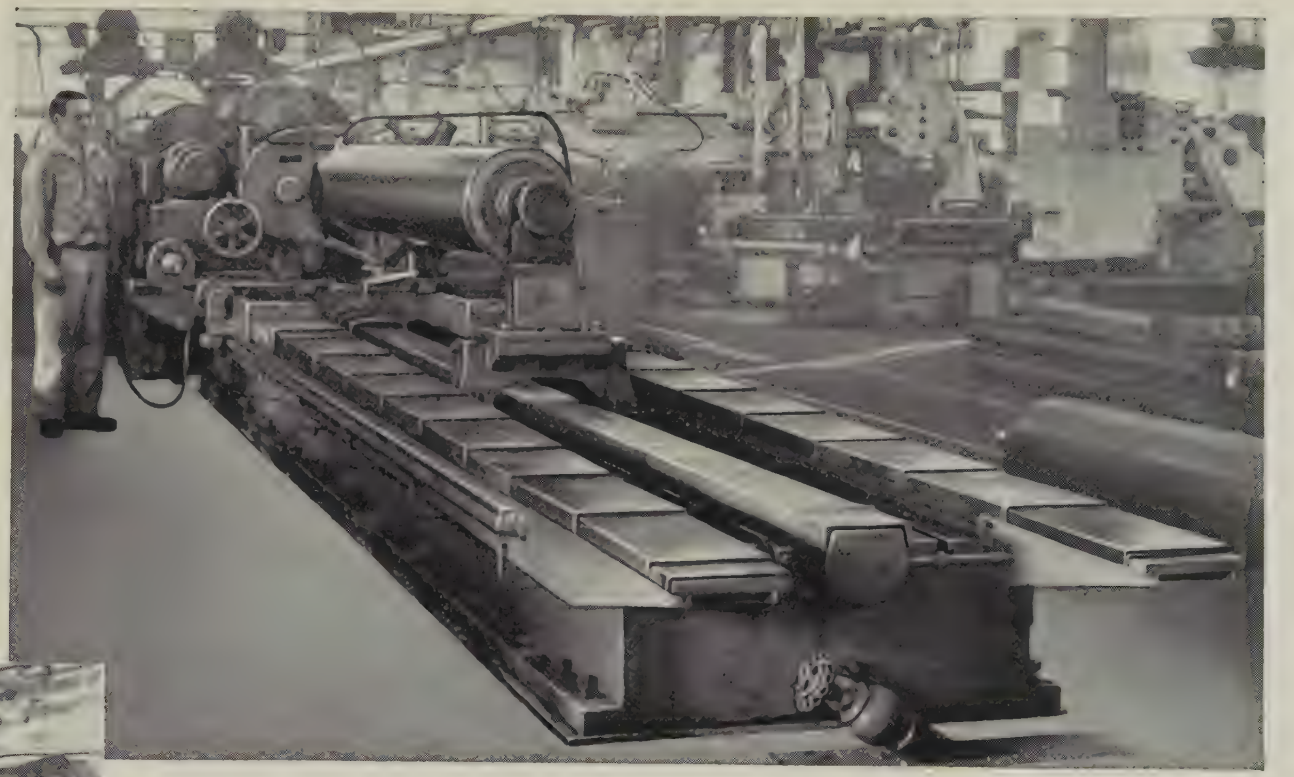

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Charles Bartell, Group Leader, Chemical Research, Dewey & Almy Chemical Div., W. R. Grace & Co., Cambridge, Mass., a 1942 graduate of Ohio State University, with a Ph.D. degree in 1951.

Ralph W. Bauer, Research Chemist, Columbia-Southern Chemical Corp., Barberton, Ohio, a 1951 graduate of Bluffton College.

Bernard J. Becker, Chief Chemist, Standard Chemical Products, Inc., Hoboken, N. J., a 1938 graduate of Louisiana State University.

Otto T. Bierwagen, Control and Development Chemist, Eastman Tag & Label Co., Richmond, Calif., a 1948 graduate of the University of California.

Warren J. Bodendorf, Research Chemist, C. H. Dexter & Sons, Inc., Windsor Locks, Conn., a 1947 graduate of the University of Massachusetts.

Guillermo Carvajal, Assistant Production Manager, Carvajal & Cia. Ltda., Cali, Colombia, S. A., a 1954 graduate of Carnegie Institute of Technology.

Charles E. Cilley, Assistant Manager of Research, Masonite Corp., Ukiah, Calif., a 1950 graduate of the University of New Hampshire.

Roy A. Dougans, Apparatus Sales Engineer, Canadian General Electric Co. Ltd., Vancouver, B. C., Canada, a 1949 graduate of the University of British Columbia.

Hessel E. Duintjer, Managing Director, Duintjer Wilkens Meihuizen & Co., N. V., Veendam, Holland.

William B. Earthman, Jr., Development Engineer, International Paper Co., Georgetown, S. C., a 1955 graduate of Mississippi State College.

Myrtle C. Fraley, Principal Order Librarian, Newark Public Library, Newark, N. J.

Edwin B. Frost, Sales Representative, Southern Clays, Inc., New York, N. Y., a 1953 graduate of the University of Maine.

Robert P. Fuller, General Manager, Lydall & Foulds Paper Co. and Colonial Boards, Manchester, Conn., a 1944 graduate of Johns Hopkins University.

Glauco M. Gaeta, Pulp and Paper Machinery Merchant, E.S.S.E. Organizazione Scambi Internazional, Milan, Italy.

Sidney C. Gough, Plant Engineer, Canadian Johns-Manville, North Bay, Ont., Canada.

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Jean F. Gschwind, Vice-President, J. O. Ross Engineering Div., Midland-Ross Corp., New York, N. Y., a 1927 graduate of Swiss Federal Institute of Technology.

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Sherrill G. Hazard, Jr., Student, State University College of Forestry, Syracuse, N. Y.

Rainer R. Hoffmann, Lawyer, Molino Fenix S. A., Rosario, Province of Santa Fe, Argentina.

Richard A. Kraus, Technical Service Representative, Corn Products Sales Co., New Orleans, La., a 1956 graduate of The Citadel.

Frank S. Hoholik, General Manager, Manistique Pulp & Paper Co., Manistique, Mich., a 1929 graduate of Detroit University.

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Sosaku Kuge, Laboratory Worker on Photographic Paper, Mitsubishi Paper Mill, Kyoto-fu, Japan, a 1939 graduate of Nagaoka Technical College.

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P. Neogi, Chemist, Titaghur Paper Mills, West Bengal, India, a 1936 graduate of Hooghly-Mahsin College.

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Roy F. Weston, President, Roy E. Weston, Inc., Newtown Sq., Pa., a 1953 graduate of the University of Wisconsin.

Richard E. Williams, Student, New York State College of Forestry, Syracuse University, Syracuse, N. Y.

TAPPI Notes

Charles E. Adams is now Assistant Chief Chemist for St. Regis Paper Co., Pensacola, Fla.

Phillip H. Avery is now Technical Director of Rochester Paper Co., Rochester, Mich.

Sylvester W. Baird, formerly of Chicago Corrugated Box Co., is now General Foreman of the Hinde & Dauch Division, West Virginia Pulp & Paper Co., Hoboken, N. J.

James P. Bambacht, formerly student at The Institute of Paper Chemistry, is now a research chemist for Nekoosa Edwards Paper Co., Port Edwards, Wis.

Raymond I. Bashford, Jr., formerly of E. I. du Pont de Nemours & Co., is now a technical sales representative for Penick & Ford Ltd., New York, N. Y.

William C. Birdsey, formerly of the Pioneer Div., The Flintkote Co., is now with Fiberboard Paper Products Co., San Francisco, Calif.

Peter B. Borlew, formerly of Owens-Illinois Glass Co., is now Assistant Mill Manager in charge of production for Celulosa de Chihuahua S/A, Colonia Anahuac, Chihuahua, Mexico.

Carl W. Braastad is now Superintendent of Kalof Pulp & Paper Co., Port Hueneme, Calif.

Robert M. Brown is now Assistant Superintendent of the Aetna Paper Co., Dayton, Ohio.

Z. J. Chagnon, formerly of Albany Felt Co. of Canada, is now Vice-President in charge of sales for Albany Felt Co., Albany, N. Y.

Lawrence L. Clapp is now Process and Production Development Engineer for St. Regis Paper Co., Pensacola, Fla.

Russell L. Clark is now General Superintendent of Newton Falls Paper Co., Newton Falls, N. Y.

John Cochran, Technical Service Engineer for Hercules Powder Co., has been transferred from Holyoke Mass., to Syracuse, N. Y.

J. Edward Doyle is now Statistical Control Engineer for St. Regis Paper Co., Pensacola, Fla.

James S. Evans, formerly of Mead Corp., is now Mill Manager of The Wrenn Paper Co., Middletown, Ohio.

Richard W. Flores is now Quality Control Supervisor for Riegel Paper Corp., Milford, N. J.

Robert S. Guide, formerly student at The Institute of Paper Chemistry, is now a project supervisor at Longview Fibre Co., Longview, Wash., and is on leave of absence with Air Force at Wright-Patterson Air Force Base, Dayton, Ohio.

Edgar F. Guillot, technical representative for Dorr-Oliver, Inc., has been transferred from Stanford, Conn., to Tokyo, Japan.

William O. Gutzwiller, Mill Chemist for the Howard Paper Mills, has been transferred from Franklin, Ohio, to the Aetna Paper Co. Division, Dayton, Ohio.

Joseph E. Hartford is now Vice-President and General Manager of the Shartle Bros. Division, Black-Clawson Co., Middletown, Ohio.

C. S. V. Hawkings, General Superintendent of Price Bros. & Co., Ltd., has transferred from Jonquiere, P. Q., to Kenogami, P. Q., Canada.

Ralph E. Hayes is now Manager of Newsprint Manufacture, Abitibi Power & Paper Co., Toronto, Canada.

Travis Q. Holden, chemist for the Howard Paper Mills, has been transferred from Franklin, Ohio, to the Aetna Paper Co. Division, Dayton, Ohio.

William H. Holl, formerly of the Victorian Paper Mills Co., is now Assistant to the Upper Mills Manager of Riegel Paper Corp., Milford, N. J.

Jaro Holy, formerly of the Sulphite Pulp Manufacturers Research League, is now By-products Sales Representative for the Consolidated Water Power & Paper Co., Wisconsin Rapids, Wis.

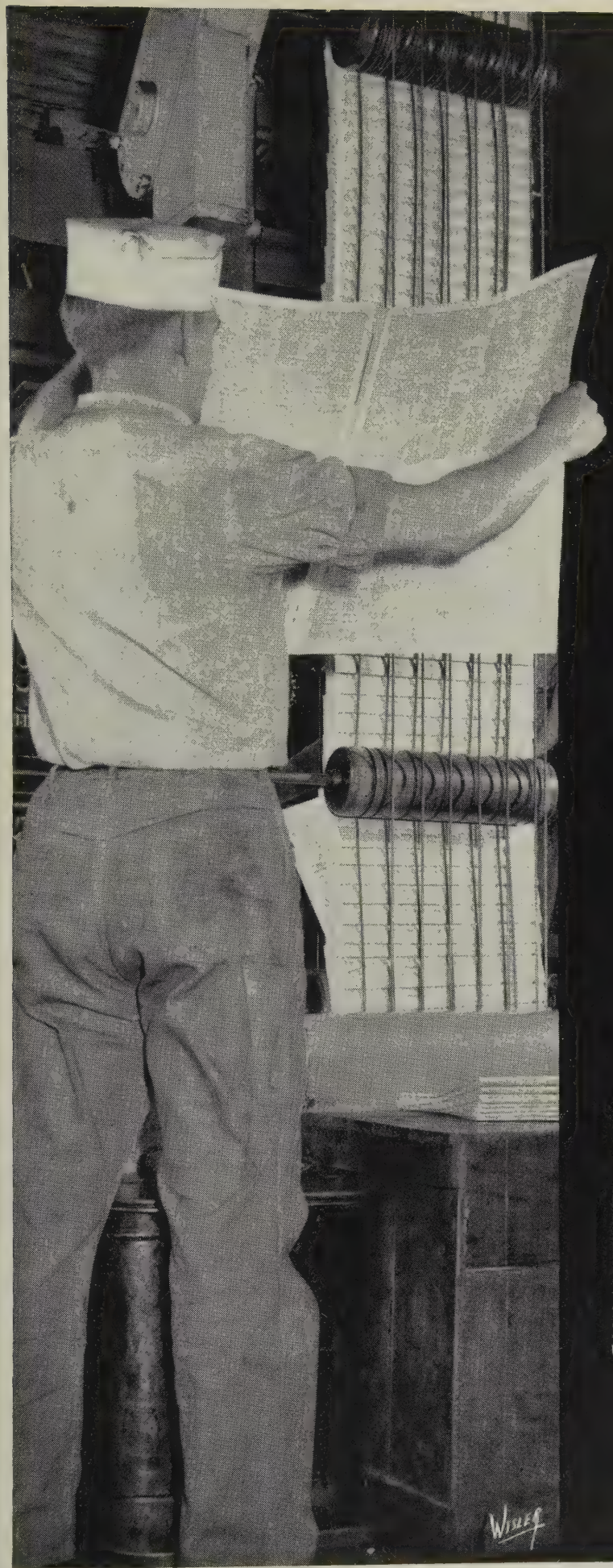
William C. Howard, engineer for the Bailey Meter Co., has been transferred from Cleveland, Ohio, to Atlanta, Ga.

Peter J. Jerardi, formerly of Baldwin Lima Hamilton Corp., is now with Beloit Iron Works, Beloit, Wis.

Richard E. Kline, formerly of Riegel Paper Corp., is now Process Control Engineer for Champion Paper & Fibre Co., Hamilton, Ohio.

Robert M. Levy, formerly of Ecusta Paper Co., is now Director of Research and Development for Allied Paper Corp., Kalamazoo, Mich.

Robert M. Ludwig, formerly of Rust Engineering Co., is now Manager of Richmond Steel Co., Inc., Norfolk, Va.



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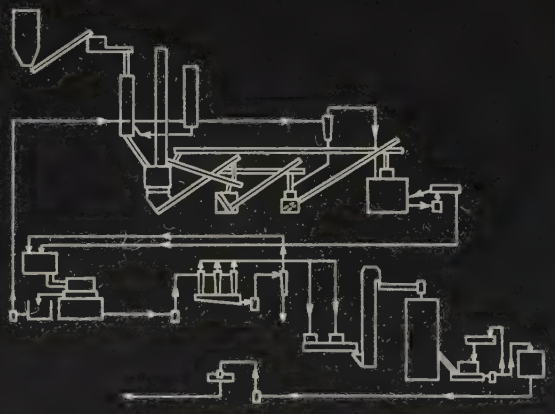

Hubert M. Lyle, research chemist for Crown Zellerbach Co., is now with the St. Francisville Paper Co., St. Francisville, La.

George E. Martin, formerly of Fibreboard Paper Products, Inc., is now a Special Assistant in Paperboard Manufacture for Champion Paper & Fibre Co., Hamilton, Ohio.

Earl S. McColley, Chief Chemist for Celanese Corp. of America, has been transferred from Rock Hill, S. C., to Cumberland, Md.

Diptendra N. Mitra, formerly of Millspaugh, Ltd., is now a project supervisor, Pulp & Paper Research Institute of Canada, Montreal, Canada.

Winship B. Moody, formerly of the U. S. Army, is now in the technical service department of Hercules Powder Co., Holyoke, Mass.

Leo Mulligan, Cellulose Insulation Specialist for the General Electric Co., has been transferred from Pittsfield, Mass., to Hudson Falls, N. Y.

Jaakko O. Murto, formerly of Metex Cooperative Corp., is now a consulting engineer with Murto and Poyry, Helsinki, Finland.

Arthur W. Olive, of Hansel Engineering Co., has been transferred from Lynnwood, Wash., to Birmingham, Ala.

Ray A. Olson is now Assistant Sales Manager for industrial products of Central Soya Co., Chicago, Ill.

Hans Osborg, Consulting Physical Chemist for Chemirod Corp., has been transferred from Port Washington, N. Y., to Milltown, N. J.

Edward W. Petrich, of the Howard Paper Mills, has been transferred from Dayton, Ohio, to Urbana, Ohio, as Production Engineer.

Jaakko Poyry, formerly engineer for Wartsila-Koncernen A/B, is now a consulting engineer for Murto & Poyry, Helsinki, Finland.

Alphonse R. Presto, formerly with Diamond Match Co., is now Plant Chemist for Buresh Non Wovens Inc., Westfield, Mass.

Frank W. Preston, formerly of New Haven Board & Carton Co., is now a paper consultant for Mount Hope Machinery Co., Taunton, Mass.

Robert C. Putnam, formerly of U. S. Testing Co., is now Director of Research for E. F. Drew & Co., Inc., Boonton, N. J.

Warren S. Rushton, formerly of McLaurin-Jones Co., is now in the technical department of Brown-Bridge Mills, Troy, Ohio.

Vincent F. Russo, formerly student at The Institute of Paper Chemistry, is now Assistant Technical Director of W. R. Grace & Co., Paramonga, Peru.

George H. Saunders, of Kimberly-Clark Corp., has been transferred from Neenah, Wis., to Munising, Mich., as Product Development Chief.

Harold J. Schlotter is now Director of Product Development for Hoerner Boxes, Inc., Keokuk, Iowa.

Fred L. Schorken, chemical engineer for Dorr-Oliver, Inc., has been transferred from Oakland, Calif., to Stamford, Conn.

Horace T. Scordas, of Union Bag-Camp Paper Corp., is now Manager of Technical Service for Containerboard Sales, New York, N. Y.

Charles J. Seiler, formerly of the General Electric Co., is now in the technical department of the Abrasive Division, Behr-Manning Corp., Troy, N. Y.

William J. Shaughnessy has returned from the U. S. Navy to the Albany Felt Co., Albany, N. Y., as a service engineer.

Abraham Siegel, formerly of Mergenthaler Linotype Co., is now a development chemist for Aerojet-General Corp., Sacramento, Calif.

J. A. Staidl, technical consultant, has transferred his office from Franklin, Va., to 2202 Kendall Ave., Madison 5, Wis.

Bryan H. Standley, formerly with Clisby-Moore, Inc., is now a sales engineer for Industrial Marine Supply Co., Pensacola, Fla.

Arthur J. Sternby is now a sales engineer for the Shartle Division, Black-Clawson Co., Middletown, Ohio.

Medie T. Still is now Chief Chemist for St. Regis Paper Co., Kraft Paper Division, Pensacola, Fla.

Harold Stokland, formerly of Vestfos Cellulosefabrik, is now a research chemist for Mesna Kartonfabrik, Lillehammer, Norway.

John Studeny is now Industrial Papers Sales Manager for Hammermill Paper Co., Erie, Pa.

James H. Tate is now Vice-President of Howard Paper Mills, Inc., Urbana, Ohio.

Curt Thies, formerly student at The Institute of Paper Chemistry, is now a student at Michigan State University, E. Lansing, Mich.

Donald E. Thornton, formerly of the U. S. Army, is now a paper chemist for the Kalamazoo Paper Co., Kalamazoo, Mich.

James S. Tipka, formerly of F. C. Huyck & Sons, is now Technical Sales and Service Representative for Scott Testers, Inc., Providence, R. I.

Henry J. Trolin is now Vice-President of Central National Corp., New York, N. Y.

P. Borje Wahlstrom, formerly of Anglo Paper Products Ltd., is now Control Superintendent of Korsnas A/B, Govle, Sweden.

Roy P. Webber, of West Virginia Pulp & Paper Co., has been transferred from Charleston, S. C., to Luke, Md., as Paper Mill Superintendent.

Curt Weil is now pulp and paper mill engineer for Ebasco Services, Inc., New York, N. Y.

William L. Williams, District Engineer for C. F. Braun & Co., has been transferred from Alhambra, Calif., to Houston, Texas.

Charles G. Wolfe, formerly of Allied Paper Corp., is now a chemical engineer for Fitchburg Paper Co., Fitchburg, Mass.

* * *

Charles M. Koon has succeeded *J. G. L. Caulfield* as the official corporate representative of the Eastern Corp., Bangor, Me., in TAPPI.

G. S. Bailey has succeeded *Elmer M. Leavitt* as the corporate representative of North Carolina Pulp Co., Plymouth, N. C., in the Technical Association.

H. N. Hirsch has succeeded *C. J. Mijburgh* as the corporate representative of South African Pulp and Paper Industries, Ltd., Mandini, Zululand, Natal, S. A., in TAPPI.

John G. Wilson has succeeded *Charles Sylvester* as the corporate representative in TAPPI of the Australian Paper Mfgrs. Ltd., Melbourne, Australia.

Norbert A. Seidensticker, President and General Manager, has succeeded *F. L. Zellers* (retired) as the corporate representative of the Chillicothe Paper Co. in the Technical Association.

* * *

T. S. DeWoody has succeeded *L. R. McCoy* as the official representative in TAPPI of the Diamond Alkali Co., Painesville, Ohio.

George E. Olson has succeeded *R. E. Ten Hoor* as the official representative in the Technical Association of the Dow Chemical Co., Midland, Mich.

Henry S. Dimmick has succeeded *P. W. Dunlap* as the official representative in TAPPI of SKF Industries, Inc., Philadelphia, Pa.

Industry Notes

PRODUCTION

Paper and board production during August amounted to

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Whatever type of paper, paperboard or fiberboard you produce, your sizing problems can be lessened by use of a Nopco-developed wax size.

Nopco wax sizes—the result of long and tireless research—assure positive wax retention on the fibers, thorough and even wax distribution through the sheet, high efficiency at low cost. As many as 21 different formulations are available to give your product any combination of properties needed.

For complete information about Nopco wax sizes, write for your copy of "Wax Sizes for the Paper Industry." Nopco Chemical Company, 60 Park Place, Newark, N.J.

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2,675,876 tons. This was slightly below the 2,679,580 tons produced in August a year ago. Paper production amounted to 1,136,985 tons, which was 2% below the 1,154,229 tons produced in August a year ago. The output of paperboard during this month was 1,250,498 tons, reflecting a 2% increase above the production of 1,244,767 tons reported for August, 1957.

Paper and board production during September amounted to 2,656,538 short tons. This was approximately 6% above the 2,151,046 tons produced in September a year ago. Paper production amounted to 1,125,729 tons, which was 6% above the 1,061,281 tons produced in September a year ago. The output of paperboard during this month was 1,242,358 tons, reflecting an increase of almost 5% above the production of 1,188,653 tons reported for September 1957.

Pulpwood

Pulpwood receipts at the pulp mills in August amounted to 3,098,442 cords, with consumption at 2,942,259 cords. Month-end inventories increased to 5,928,660 cords.

Pulpwood receipts at the pulp mills in September amounted to 3,025,624 cords, with consumption at 2,937,943 cords. Month-end inventories increased to 6,062,871 cords.

Wastepaper

Consumption of fibrous materials other than pulpwood, totaled 869,310 tons in August, compared to 830,658 tons in August, 1957. Inventories of 816,776 tons of month's end reflected a 5% decrease under end of July inventories. Consumption of wastepaper amounted to 780,250 tons, as compared to the 735,598 tons consumed in August a year ago.

Consumption of fibrous materials other than pulpwood, totaled 878,085 tons in September, compared to 808,844 tons in September, 1957. Inventories of 795,522 tons of month's end reflected a 2% decrease under end of August inventories. Consumption of wastepaper amounted to 785,033 tons, as compared to the 714,997 tons consumed in September a year ago.

Wood Pulp

Wood pulp production during August amounted to 1,844,232 tons as compared to 1,904,103 tons produced in August a year ago.

Wood pulp consumption in the paper and board mills during August, amounted to 1,936,068 tons, compared to the 1,958,113 tons consumed in August a year ago.

Wood pulp inventories at the end of August at the paper and board mills, amounted to 537,915 tons, as compared to 550,615 tons reported at the end of July. Month-end stocks of the pulp mills were 265,335 tons, as compared to 275,974 tons reported at the end of July.

Wood pulp production during September amounted to 1,816,678 tons as compared to 1,751,326 tons produced in September a year ago.

Wood pulp consumption in the paper and board mills during September amounted to 1,922,955 tons, compared to the 1,812,147 tons consumed in September a year ago.

Wood pulp inventories at the end of September at the paper and board mills amounted to 534,423 tons, as compared to 537,433 tons reported at the end of August. Month-end stocks at the pulp mills were 259,630 tons, as compared to 265,574 tons reported at the end of August.

Paperboard

Demand for paperboard during 1959 is expected to be about 5% above the 1958 level, Peter Hoguet, president, The Econometric Institute, told the nation's paperboard officials assembled in New York recently for the 26th Annual Meeting of National Paperboard Association.

Containerboard, used for corrugated shipping containers will probably show one of the largest gains in 1959, Mr. Hoguet said. These production rises will be attributable to the expected continued improvement in the over-all economy. Consumer purchasing power is likely to move steadily upward through the remainder of this year and throughout 1959. Some increases in prices at both the consumer and wholesale level are likely but these will most likely be much less than income gains. Consequently real consumer purchasing power will continue a rising trend throughout 1959. All of these factors tend to raise the demand for paperboard for all types of packaging, Mr. Hoguet declared.

A.C.S.

Response from the pulp and paper industries to the American Chemical Society building fund drive has been highly encouraging to date, reports John B. Calkin, campaign chairman for this industrial category.

J. B. Calkin, Calkin & Bayley, Inc.

Contributions from pulp and paper companies during the first six weeks of his solicitation total 18% of the group's quota, according to Mr. Calkin, who is president of Calkin & Bayley, Inc., industrial consultants, of New York. Edward R. Weidlein, retired president of the Mellon Institute, is general chairman of the industrial drive.

The fund campaign, first of its kind in the Society's 82-year history, seeks $3,000,000 for construction of a new national headquarters in Washington to provide the additional space needed to expand the Society's services to the profession and the chemical industry.

National Technical Task Committee

The National Technical Task Committee for Industrial Wastes held its ninth annual meeting December 11–12 at Cincinnati with 52 scientists and engineers representing most of the nation's major industries in attendance.

The Task Committee, chaired by Richard D. Hoak, Senior Fellow of the Mellon Institute, Pittsburgh, continued to direct its attention both to immediate and long range planning concerning problems related to industrial wastes. The committee was created in 1950 by the Surgeon General of the United States Health Service. It serves as an industry forum on waste problems and as an advisory group to P.H.S.

During the business meeting the following were elected officers for the coming year: Ray S. Glynn, director of sanitation research and development, Association of American Railroads, chairman; A. J. Steffen, director of sanitary engineering, Research and Technical Division, Wilson & Co., Inc., Chicago, vice-chairman; L. S. Warrick, sanitary engineer director, Technical Services Consultant, Water Supply and Water Pollution Control Program, Public Health Service, secretary.

The report of Task Group III—Chemical Processing is reproduced below insofar as it applies to the industry:

During 1958 the pulp, paper, and paperboard industry increased its response to the very apparent need for fundamental studies on water pollution and waste treatment problems. Through the National Council for Stream Improvement, research on the ultimate use of streams for carrying pulping effluents while maintaining classification requirements was carried out by Professor Clarence J. Velz at the University of Michigan. Much basic information regarding the oxygen requirements of fish was obtained by aquatic biologists at the University of Georgia and Oregon State College, the latter project carried on in cooperation with the United States Public Health Service group stationed at that institution. The problem of river slime growths has received much attention both in the laboratory and the field. The effects of algae on the oxygen balance in streams are being studied by the

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You should, for the production problems they solve could mean a lot to YOU!

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***pro·duc'tion·eer'** (pro·duk'shun·ir'), *n.* 1. One who works for, or in the interest of, more efficient and economical production, increased production, etc. 2. One who contributes to the production of goods of economic value.

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New York • Philadelphia • San Francisco • St. Louis

Wisconsin Sulfite Pulp Manufacturer's League, with the Wisconsin Committee on Water Pollution and the State Board of Health.

Dewatering and disposal of sludges obtained from the clarification of pulp and paper mill effluents is receiving attention at Syracuse University and Kalamazoo College, and in a number of mill development projects. Stream reaeration by means of turbine reaeration and high efficiency sparging is under investigation by the Wisconsin Sulfite Pulp Manufacturer's League and the council at the University of Maine.

Removal of color from bleachery effluents with recovery of the lignin chlorides in the form of heat or a by-product, is being studied at Louisiana State University and several southern mills. At Bates College, the odor control problem in lagoons and surface waters is receiving attention. Very rapid advancement in both process development and practice with respect to recovery of acid and neutral sulphite pulping liquors is under way. Two new sulfite recovery methods, the Magnesite process and ASI system, are now being extensively investigated.

Progress in removal of suspended solids from wood room effluent continues with the installation of several new types of screening devices at individual mills. Slowly but surely lignin utilization is increasing as new uses for products made from spent pulp cooling liquor solids are being found.

Biological oxidation for BOD removal is gaining wider acceptance and three full-scale plants are under construction. The effect of pulp mill effluents on oyster culture is under investigation by the Department of Fish and Game Management at Oregon State College.

In summary, it can be stated that the expenditures for research, development, and practice of water pollution control by the pulp, paper, and paperboard industries have increased during 1958. Cooperation of the industry with regulatory agencies in all these fields of endeavor is in the ascendancy.

Forest Service

"Forestry and Deer in the Pine Region of New Jersey" is the title of Station Paper No. 109 published by the Northeastern Forest Experiment Station, Forest Service, United States Dept. of Agriculture, Upper Darby, Pa. This book, authored by S. Little, G. R. Moorehead, and H. A. Somers, is a summary of our present knowledge of relationships between forestry and deer.

"1957 Pulpwood Production in the South," by J. F. McCormack, Division of Forest Economics Research of the Department of Agriculture Forest Service, was released in September as "Forest Survey Release No. 53."

The report on the forest survey of Mississippi has been published by the Southern Forest Experiment Station, Department of Agriculture Forest Service, New Orleans, La., under the title of "Mississippi Forests."

Simpson

A new Simpson Logging Co. product, random, drill calendered acoustical tile, was announced to customers all over the United States in November.

The new design features three sizes of holes carefully arranged in the smoothly surfaced tile to show no set pattern at all.

Announcement of this latest addition to Simpson's family of forest products emphasized the availability of the newcomer.

KVP

On October 9, KVP Co. President Dwight L. Stocker announced that the company would immediately exercise its option to purchase 15 acres of land owned by the city of Griffin, Ga., and before the year was out would begin construction of its eighth plant, fifth in the United States. On this same day, the *Griffin Daily News* carried the front page headline "Paper Products Company Will Locate New Plant in Griffin." For both KVP and Griffin it was important and stimulating news.

Warehousing and paper converting facilities are included in the plans for this new 30,000 sq. ft. plant to be built at a total cost of nearly $300,000. Printing, waxing, rewinding, and sheeting are among the converting operations which are scheduled to begin next spring. Initially, the company plans to employ between 25 and 50 residents of Griffin and the surrounding area.

A community of about 25,000 people and county seat of Spalding County, Griffin is located 40 miles south of Atlanta where KVP has an established sales office headed by salesman Jim Thornton.

A study of distribution patterns of KVP products to customers and potential markets in the southeastern section of the United States underlined the advisability of building a plant near Atlanta. After intensive search and visits to some 20 sites in the Atlanta area by Kalamazoo plant's Assistant General Superintendent Preston Carter, Griffin was chosen as the site for KVP's new plant.

Consolidated Water Power & Paper

Three personnel appointments in the engineering department of Consolidated Water Power & Paper Co. were announced by M. V. Molsberry, chief engineer.

James W. Taylor has been named to head the newly organized steam, combustion, and instrumentation section of the department. In this section Norman Dietrich will serve as assistant steam and combustion engineer and George Davis as assistant engineer for steam distribution and utilization.

Two personnel appointments have been announced by Consolidated Water Power & Paper Co.

Frank F. Oehme has joined the coated paper section of Consolidated Water Power & Paper Co.'s research and development department, it was announced by S. G. Holt, research and development manager. Mr. Oehme will serve as the senior printing technician. He has been employed by W. A. Krueger Co., Milwaukee, for the past year.

Ray W. Plenge has been appointed tour foreman on no 3. paper machine at the Wisconsin Rapids Division of Consolidated Water Power & Paper Co., it was announced by Otto Hassel, board superintendent.

Hammermill

John Studeny, a TAPPI member, has been appointed sales manager, industrial papers, Hammermill Paper Co., Erie, Pa. Mr. Studeny also serves on the Technical Committee of the Writing Paper Manufacturers' Association.

Wrenn

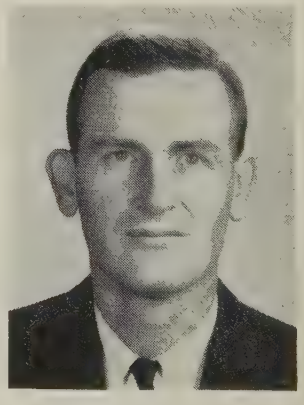
James S. Evans has been named mill manager of The Wrenn Paper Co., Middletown, Ohio, it was announced November 21 by J. J. Hallowell, president.

Mr. Evans, director of production-quality control at The Mead Corporation's Kingsport, Tennessee Division, assumed his new duties on Jan. 1, 1959.

Allied

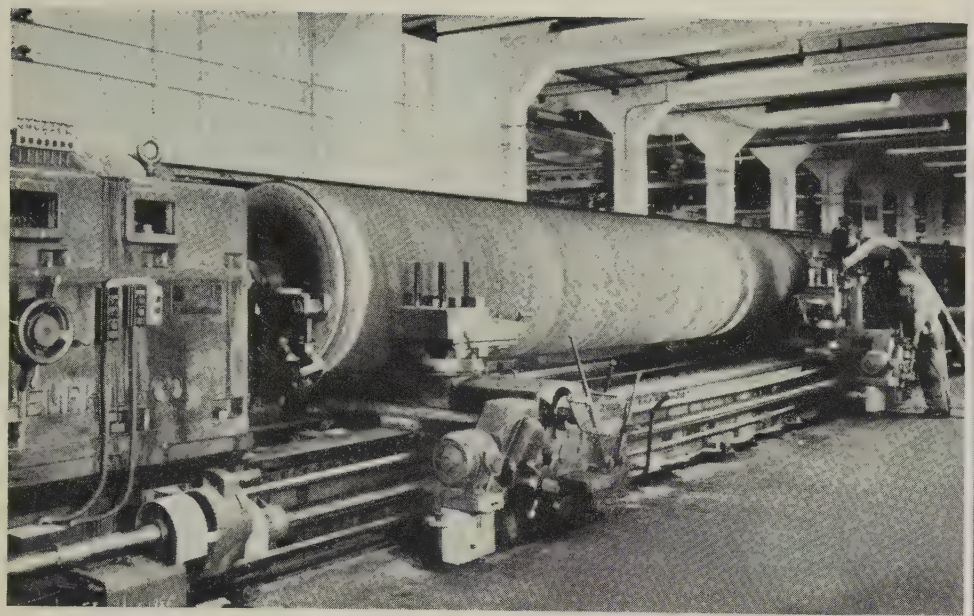
Millard C. Teague has been named director of quality control and Robert M. Levy has been appointed director of research and development for Allied Paper Corp.

John Studeny, Hammermill Paper Co.



J. S. Evans, The Wrenn Paper Co.

LOOK TO THE COVER FOR BEST ROLL PERFORMANCE



One of five suction press rolls in preparation, each 30 feet long and 50 inches in diameter, rubber covered by Manhattan for the world's largest paper machine, located in Canada.

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- ***No Pick-up . . . . No Crush***
- ***Better Water Removal at Lower Dryer-Steam Costs***

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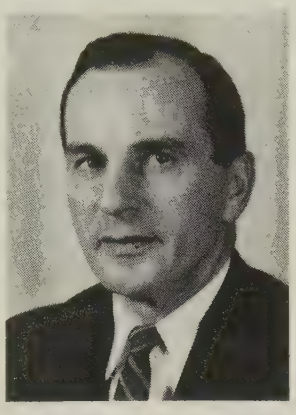
According to the announcement made by President Ward D. Harrison in Kalamazoo, Mich., they assumed their new responsibilities in December.

Both men have been associated with the Ecusta Paper Corp., Pisgah Forest, N. C., for almost 20 years.

Chillicothe

Directors of the Chillicothe Paper Co., Chillicothe, Ohio, elected N. A. Siedensticker president and general manager and E. A. Hoey vice-president and sales manager at its annual meeting November 28, it was announced by D. F. Morris, president of The Mead Corp., Dayton, Ohio. Chillicothe Paper Co., manufacturers of fine white papers since 1919, is a wholly-owned subsidiary of Mead.



N. A. Siedensticker, Chillicothe Paper Co.

The newly-elected president succeeds Austin P. Story, who is retiring after 16 years as chief executive. Mr. Story, associated with the company since the date of incorporation, June 21, 1919, was elected as its second president and general manager in 1942.

Crossett

Production capacity of Crossett Paper Mills' bleached food board mill will be expanded by one third with a $3,400,000 building program to be started as soon as possible, The Crossett Co. revealed today.

The announcement, released by J. C. Hair, manager of The Crossett Co.'s Paper Division, said the expansion will be accomplished by the addition of more drying units to the existing cylinder board machine, and the installation of additional refining equipment. There will also be some minor changes in the hardwood pulp mill and bleach plant.

No new employees will be added to the work force by virtue of this expansion, Mr. Hair said.

About $130,000 is to be spent during the coming year to build a bark storage bin at Crossett's kraft paper mill to provide more even and efficient burning of bark.

Engineering by Rust Engineering Co. of Birmingham, Ala., is already underway and orders will be placed for building materials and equipment at the earliest possible moment. Construction will be by contract. It is hoped that the project can be completed by "early 1960," the mill manager said.

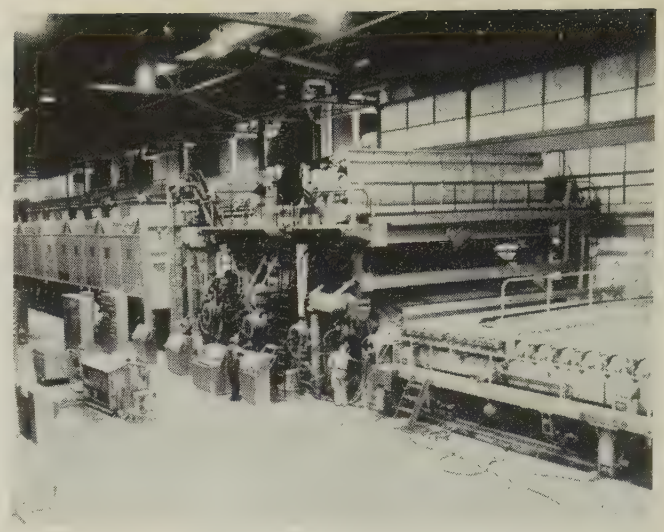
The program calls for the addition of 29 new driers to the company's cylinder machine. With this new equipment, daily production of bleached food board can be increased from 160 to 215 tons. This will be possible because the additional driers will have the capacity to permit increased operating speeds on the cylinder machine. In the past, the big machine has been limited by fewer driers.

The new appropriation brings to over $9 million the amount of money invested by The Crossett Co. in expansion of its paper division during a three-year period beginning in late 1956. Counting the bleached food board mill, put into production in 1955, this total amounts to over $25 million within four years.

Southland

Announcement was made recently of an exceptional start-up of a new paper machine at Southland Paper Mills, Lufkin, Tex. Sidney G. Briscoe, general sales manager of the Pusey and Jones Corp., said the 270-in. fourdrinier machine produced press-ready paper within 90 min. after it was started.

The machine, the third which Southland has purchased from



New Pusey & Jones paper machine at Southland Paper Mills

the Pusey and Jones, is now ready to run at 2500 f.p.m., its designed speed. Presently, the unit is producing newsprint.

The fourdrinier wire is 118 ft. long. The machine uses an air pressure type headbox and slice with crossflow stock distributor. The fourdrinier section is equipped with the Pusey and Jones developed Rapi-Drape wire handling system which permits quick changing and predraping of the wire. Hydraulic units raise and lower the 34 in. diameter breast roll and operate the wire changer assembly.

Built at a cost of $3,000,000, the new machine has a five-suction roll press part and 65 driers. Fifty-five of these 60 in. diameter driers are paper driers, eight are for felts and the remaining unit is a sweat drier. The drier section has high speed, enclosed gearing, steam joints with dual revolving siphons, and an automatic, motorized felt take-up and tension control. Bearings and gears are lubricated with a Bowser system. The sheet is threaded with a rope carrier, and the complete drier section is enclosed within a Ross hood.

The eight roll calender stack and horizontal track reel are located 400 ft. from the headbox. The stack has an electric lifting system, Vickery-type doctors, and a Bowser lubricating system.

Riegel

Riegel Paper Corp., New York, N. Y., has announced the acquisition of Quality Lithographing Co., Atlanta, in exchange for 14,122 shares of Riegel common stock.

The business will be conducted under the name of Quality Lithographing Division, Riegel Paper Corp. C. W. Barr, formerly president of Quality, will continue as general manager of the new division.

Rhinelander

A forward step in the Rhinelander Paper Co.'s long range plan of modernization has just been taken with the completion of the $4.5 million project to improve both steam and electric generating capacity.

According to Ripco management, they have been somewhat "short" on steam output and electric energy. The new project not only relieves that shortage, but at the same time will give the mill ample power potential in preparing for any possible future expansion.

Key to the project was the construction of a large addition to the plant, which began in the spring of 1957. The modern building, built of concrete, steel, and transite, is 58 by 71 ft. in size, and rises 127 ft. in the air to accommodate the new boiler.

The boiler, costing $1,320,000 itself, without auxiliary equipment, was manufactured by Babcock and Wilcox, Barbertown, Ohio and is known as a cyclone furnace type.

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Capacity of the boiler is 260,000 lb. of steam per hour at 1500 p.s.i. at 950°F. The furnace burns a lower grade of midwest coal, yet is more efficient than the five boilers presently in operation, which now burn a higher grade of eastern coal. The coal is crushed here to a size of one quarter inch to 28 mesh and is fed into the furnace by an automatic mechanism.

The ash is melted and run out of the bottom of the furnace as molten slag. The furnace will burn 264 tons of coal a day—roughly about five railroad carloads. The boiler is capable of evaporating 600 gal. of water a minute at full capacity.

A water treatment plant, costing about $160,000, was erected adjoining the boiler plant to prepare water for use in the new boiler. The plant filters and demineralizes water from the Wisconsin river. Two feed pumps send water to the boiler at 2000 lb. pressure. One pump is driven by a 1000-hp. electric motor, the other by a steam turbine of the same horsepower.

As part of the new system, a turbine generator of the extraction back-pressure type was installed in a new room built adjacent to the present turbine room. The new building is of brick construction and tiled inside to match the present turbine room.

Manufactured by Westinghouse, the new turbine has a rated capacity of 10,000 kw. at 12,500 v. It takes steam at 1500 p.s.i., extracts it at 400 p.s.i., and exhausts at 125 p.s.i. The 400-lb. steam is fed to the two other turbine generators, while the 125-lb. steam is to be used for other paper and pulp processing. Cost of the basic turbine and generator was about $579,068.

Oxford

Harold M. Annis of Chappaqua, N. Y., has been elected vice-president, research and development, of the Oxford Paper Co., it was announced December 22 by William H. Chisholm, president of Oxford. This is a new position in the company, Mr. Chisholm said, and its creation emphasizes the importance of research and development in Oxford's growth.

Mr. Annis was elected to this position with a background of 22 years of service at Oxford, having served as technical director, manager of sales service, manager of product development, and assistant to the vice-president in charge of manufacturing.

H. M. Annis, Oxford Paper Co.

Mr. Annis' earlier experience in the paper industry was in technical service at the Mead Corp., and as technical director of Allied Paper Mills.

Mr. Annis is a member of the Executive Committee of the Technical Association of the Pulp and Paper Industry and has been nominated to be its vice-president.

West Virginia

West Virginia Pulp and Paper Co. has continued its vigorous growth during the current recession, which now appears to have passed the low point, David L. Luke, president, told members of the Richmond (Va.) Society of Security Analysts recently.

Mr. Luke said the company was engaged in a $200 million rebuilding program, about three fourths completed, which will give it as much capacity in three plants at Covington, Va.; Charleston, S. C.; and Luke, Md., as it had at the end of the war in all six of its mills.

Mr. Luke declared that the company also had expanded its chemical operations; added the manufacture of building boards to its Tyrone, Pa., operations; acquired subsidiaries in Brazil and Canada; and extended its operations for manufacturing finished paper products.

By building additional corrugated container plants, the capacity of the company's H&D Division, acquired a few years ago, has been increased by about 50% and now absorbs a considerable portion of the company's paperboard production, Mr. Luke reported.

In line with the company's expanding interest in bleached board, the company acquired a little more than a year ago Virginia Folding Box Co. of Richmond, the country's leading producer of crush-proof cigarette boxes and a major producer of the cartons that carry both soft and hard-pack cigarettes.

Mr. Luke said that in recent months the company had begun its own production and distribution of grocery and shopping bags at Charleston, S. C., and had become a major producer of multiwall shipping bags through the acquisition of manufacturing operations in New Orleans, St. Louis, Wellsburg, W. Va., and Torrance, Calif.

"Fortified by our new Clupak stretchable paper," he said, "we expect to achieve a solid market position in the bag business while continuing to serve our good customers among the independent producers of bags."

While rebuilding and expanding its physical facilities, the company has strengthened its human organization, placed greater emphasis on marketing and market research, intensified its sales activity and broadened even further its fruitful product development and research programs, the analysts were told.

Mr. Luke reported that the company has been more than ordinarily sensitive to the impact of the business recession because its $200 million improvement program has added heavily to current operating expenses.

He said that West Virginia's 1958 earnings, for the first nine months about 30% below those for the same period last year, also have suffered because of the long time required to break in and bring to optimum performance major new production facilities installed in the company's mills before the recession.

"Current indications are that the low point of the recession has passed," Mr. Luke said. "This means that we may have passed the low point in our earnings, especially if the price structure of our industry is strong enough and resilient enough to cover cost increases as they develop."

He pointed out that the dollar volume of West Virginia's sales, aided by the acquisition of converting operations, has continued to grow through the recession. Both sales and

earnings should respond to the improvement in the general business situation, he said.

Mr. Luke said the paper industry should be more stable and prosperous in the future than in prewar years because destructive overcapacity which once plagued the business is unlikely to recur.

The basic cause of past disruptions in the industry no longer exist because of fundamental changes in world supply of wood pulp, the primary material of the industry, Mr. Luke said. Because efficient, integrated operations have made the cost of producing wood pulp in the United States among the lowest in the world, this country has been a major net exporter of pulp in most years since 1950, instead of a major net importer, he explained.

"Even though moderate excesses of pulp may appear on our markets from time to time as a result of temporary conditions," Mr. Luke said, "our industry has grown so large that the absolute amounts which produced disruption a generation ago would now produce only mild and transient difficulties."

Mr. Luke said that intelligent decision-making on the part of management, which he attributed in part to better and more complete information on markets, operations and productive capacity being made available by the Federal government and trade associations, had limited excess capacity to moderate proportions.

He pointed out, too, that the large amounts of well-located wood and water and the large amounts of money needed to make sizable additions to the industry's capacity would act as deterrents to undisciplined overexpansion.

"By careful scientific management of the forests, this country can look forward to a perpetual annual crop of pulpwood sufficient for its needs," he said. "But wood so procured has a substantial cost of production and one that tends to rise."

Satisfactory sites which can provide a good quality of water in adequate amounts, including streams which can absorb effluents without excessive anitpollution costs, are getting fewer and farther between, as well as more expensive, Mr. Luke said.

He pointed out that it now costs an average of about $100,000 or more per ton to build new papermaking capacity and that to add as much as one third to the capacity of the industry today would call for an investment in excess of $3 billion.

He said, however, that he expected the demand for paper and other products of wood pulp to continue to grow at a vigorous rate because of their versatility and economy. The industry's growth has averaged about 4% compounded during the last half century, he said, which means a doubling of capacity every 18 years.

He pointed out that even with its greater volume, the industry has been able to operate its mills during 1958, a recession year, at a monthly average of 85% of capacity, measured on a historical six-day-week basis.

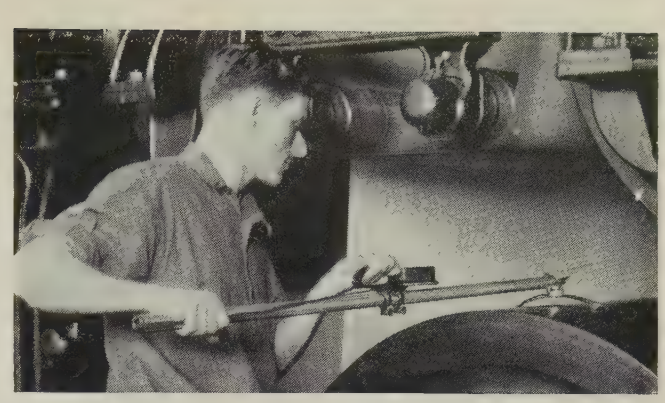
Bird & Son

Bird & Son purchased on September 2 the George W. Dinsmoor Co. of Lawrence, Mass. This company manufactures paper cores, textile board, convolute tubes, and other paper specialties.

Founded by George W. Dinsmoor in 1895, the company employs 30 people. No changes are contemplated in the internal operation of the business, although its purchase now makes it a wholly-owned subsidiary of Bird & Son. The George W. Dinsmoor Co. will continue as formerly to sell to the trade, and Bird fiber box salesmen are also selling products made by the Dinsmoor Co.

Union Bag

A new method of dewatering neutral sulphite semichemical (NSSC) pulp by means of vibrating screens has resulted in lower than normal horsepower requirements for the refiners at Union Bag-Camp Paper Corp.'s vast mill at Savannah, Ga.



A MONEY SAVER

The Cambridge Surface Pyrometer enables the paper maker to maintain the desired progressive temperature change in the drying roll train. Thus production may be safely speeded up to the maximum and a common cause of spots, cockle, curl and blister avoided. This instrument quickly and accurately determines surface temperatures of moving or stationary rolls. Ruggedly built for shop use. The Cambridge is made in a hand model and with the extension attachment to reach those hard-to-get-at places.

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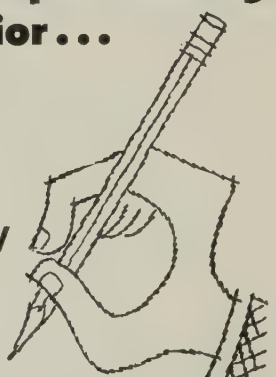

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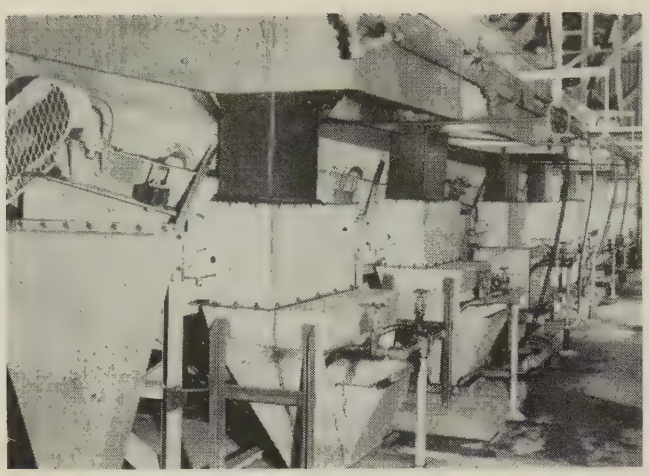


Six Link-Belt NRM-135 liquid vibrating screens reduce the moisture content of neutral sulphite semichemical pulp from about 94% to 75%, providing a uniform feed for the refiners at Union Bag-Camp Paper Corp. mill, Savannah, Ga. Effective dewatering has resulted in lower than normal horsepower requirements for the refiners

At this mill, considered to be the largest of its kind in the world, the unwashed, unrefined NSSC pulp is blown from the digesters and pumped from the blow tanks to a battery of six Link-Belt NRM-135 liquid vibrating screens, which reduce the moisture content from 94 to 75%.

At this very high consistency the pulp is then fed to the refiners, on the floor below, where the softened chips in the pulp are broken up mechanically. Each refiner has a capacity of 50 tons of finished pulp daily.

This drainage is accomplished in about 2 ft. of travel instead of by dragging the pulp 10 or 12 ft., as is normally the practice, and a more uniform dewatering has resulted.

K-C

Kimberly-Clark Corp. has announced the establishment of new scientific positions in research and development and appointment of the first senior research associate under the new program.

Walter Roehr, a recognized expert in the graphic art field, is the new senior research associate, according to W. H. Swanson, vice-president in charge of research and development for Kimberly-Clark, who made the announcement.

Mr. Roehr, a graduate of DePauw and of Washington University from which he recieved his master's and doctor's degrees, has been associated with Kimberly-Clark since 1934. He has contributed to the development of two paper testing instruments now standard in the paper industry. One is the base sheet formation tester now marketed as the Thwing Formation Tester. The other is the Rotary Rupture and Pick Tester, recognized by authorities in this field as one of the best instruments for measuring pick and rupture characteristics of paper. He has played the major role in development of routine control test procedures for letterpress and rotogravure printing used in Kimberly-Clark. "These tests have stood the test of time in our mills and research laboratories for the last 15 years," Swanson explained. Roehr's study, started in 1934, on interaction between paper surfaces and printing inks lead to Kimberly-Clark's development of heavily coated papers and to his recognition as an expert in the graphic arts field.

A Phi Beta Kappa and a Rockefeller Foundation Fellow, Mr. Roehr was a Rockefeller Foundation Research Associate prior to his joining the Kimberly-Clark Corp.

Mr. Swanson said the new scientific positions of senior research associate and research associate now established by Kimberly-Clark have as their purpose "formal recognition to research and development people who have excelled in scientific work and to provide a path for continued advancement in science paralleling that existing in technical administration." The qualifications for such an appointment, made only by the vice-president of research and development, include proved exceptional ability to make scientific contributions without any, or with very little, direction, major scientific contributions, demonstrated promise of continued contributions and willingness to foster scientific growth in others. He also must have stature and reputation for outstanding scientific competency not only among his colleagues in research and development and other divisions of the corporation but in industry outside of Kimberly-Clark as well. He also must be well recognized as an authority in his specialized field.

Walter Roehr and W. H. Swanson

St. Regis

The Carthage, N. Y., mill of the St. Regis Paper Co. was reopened November 24. The mill has been closed since April, 1957, when operations were terminated due to a drop in the demand for the products made at the mill.

Built in 1901 by the Champion Paper Co., the mill was acquired by St. Regis in 1924. Through the years various paper products have been manufactured: bag paper, bags, paper toweling, and lightweight directory paper.

Approximately 70 people have been hired to man the mill which is producing about 70 tons of kraft and crepe papers daily. The bulk of those employed are former Carthage employees.

Winslow B. Mills, the mill manager, is no stranger to the area. Mr. Mills served as superintendent at the Herrings, Carthage, and Watertown Mills from 1949 to 1953.

From 1953 to July, 1958, he was general superintendent of the company's kraft center at Pensacola, Fla. Since last July Mr. Mills has been with the company's northern specialty kraft paper sales division.

Mr. Mills is originally from Howland, Me. He has been in the papermaking field since 1917 when he joined the Advance Bag Co. in Howland. He became associated with St. Regis in 1939; prior to that he worked for the International Paper Co., Oxford Paper Co., and the Gilman Paper Co.

Mr. Mills and his wife are presently living in Watertown.

St. Regis Paper Co. and the F. J. Kress Box Co., Pittsburgh, Pa., jointly announce a merger agreement based on an exchange of two and one-quarter shares of St. Regis common stock for each share of Kress. The latter has outstanding 128,000 shares of capital stock.

Kress Box, a long established manufacturer of corrugated and fiber shipping containers, operates plants at Pittsburgh, Pa.; Newark, Ohio; Washington, Pa., and Hagerstown, Md., with a total capacity of 6,000,000 sq. ft. of daily production. Sales of Kress in 1958 will approximate $20,000,000 and the

company provides employment for some 900 persons at its four plants.

Organized in 1880 as a manufacturer of wooden boxes, Kress was one of the first United States manufacturers to produce a corrugated box, and pioneered many developments in the industry since the company began the transition from wooden to fiberboard in 1911.

On consummation of the merger, it is indicated Kress Box will be operated as a division of St. Regis, but with the same management and management policies. Present officers, who will continue in these posts, are:

J. Burk LeClere, president
Philip B. Duffy, executive vice-president
James B. Lytle, vice-president and treasurer
Joseph R. McLaughlin, vice-president and sales manager
Sylvester R. Lipinski, vice-president and general production manager
Clyde O. Steck, vice-president
Robert D. Devlin, director of purchases and secretary
Thomas C. LeClere, asst. to president and director of public relations and advertising

Stock of Kress Box is held substantially by members of the company's management.

Kress Box has a long term agreement with Sonoco Products Co. providing it with virtually all of the ouput of nine point semichemical corrugated materials from Sonoco's plant at Hartsville, S. C. This plant produces 55,000 tons of board annually and its capacity is capable of being doubled by the addition of driers.

The acquisition of Kress marks a further step in St. Regis' broadening of its operations in the paper converting and container fields.

Tennessee River

The Tennessee River Pulp & Paper Co. is exercising options on land for plant site at Counce, Tenn.

The company plans to build a 500-ton capacity kraft pulp and containerboard mill at Counce.

Great Lakes

The new no. 4 paper machine in Great Lakes Paper Co., Fort William, Ont., is a Black-Clawson newsprint machine, the largest paper machine of any type, and is built to produce 32-lb. newsprint at speeds ranging from 500 to 2250 f.p.m. with a maximum production rate of 420 tons per 24 hr.

Seventy-five chief executives of the major pulp and paper companies in North America flew by charter stratocruiser to Fort William, Ont., Oct. 3 to get a first look at the world's largest paper machine. It is the new 342-in. wide Black-Clawson newsprint machine at Great Lakes Paper Co.

Fourdrinier

The fourdrinier section is preceded by an air-loaded headbox made up of the explosion chamber, distributor rolls, and adjustable slice.

The Hydroflyte 350 fourdrinier is cantilever type for quick wire change with fabricated box section beams, retractible breast roll, wire rolls, and forming table. Drive and water connections need not be disturbed during wire change. Other components include a 38 in. diameter by 347 1/4 in. long, breast roll, one primary and two auxiliary forming tables, 13 deflectors, six suction boxes, 16 r.c. table rolls 18 1/2 in. diameter by 346 7/8 in. six r.c. wire rolls 20 3/4 in. diameter by 347 1/4 in., 54 in. diameter by 344 in. drilled face bronze suction couch roll 356 1/2 in. with single box rear suction, 40 in. diameter by 346 in. wire drive roll, 28 in. diameter by 346 in. top couch roll, and save-all trays from breast roll to last suction box with direct discharge to wire pit.

Press Section

Vacuum pick-up section with automatic sheet transfer from wire to pickup felt includes 40 in. diameter by 348 in. drilled face suction pickup roll 359 in. over-all with double box, 40 in. diameter by 348 in. drilled face suction wringer roll 359 in. over-all with single box and top wringer roll 40 in. diameter by 350 in., and also a 40 in. diameter by 350 in. top transfer roll.

Fifty in. diameter by 348 in. drilled face suction transfer roll 359 1/2 in. transfer sheet from pickup felt to main press felt. First and second main suction press rolls are 50 diameter r.c. by 348 in. drilled face 359 1/2 in. over-all, and first and second main top press rolls are 48 in. diameter by 350 in. granite cover. Two 13 1/2 in. diameter by 369 1/4 in. belt driven paper rolls lead the sheet from first and second press nips.

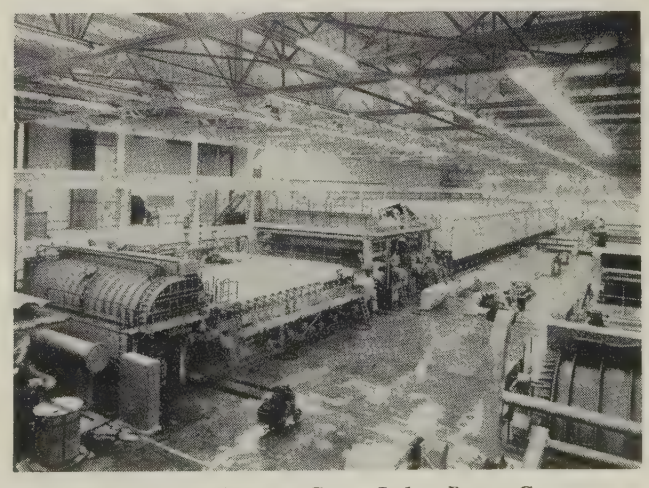
Press framing is box section design and arranged for maximum accessibility.

Drier Part

The drier part is divided into four sections with total of:

55 paper driers, 60 in. dia. by 347 in.
14 felt driers, 60 in. dia. by 347 in.
1 lead drier, 48 in. dia. by 346-1/4 in.
1 cooling drier, 60 in. dia. by 347 in.
1st section, 14 paper, 4 felt, 1 lead
2nd section, 14 paper, 4 felt
3rd section, 14 paper, 4 felt
4th section, 13 paper, 2 felt, 1 cooling

Driers are cast, semisteel, tested for 150 lb. hydrostatic pressure permitting working steam pressure of 75 lb., mounted on heavy-duty roller bearings.



No. 4 machine at Great Lakes Paper Co.

Inspecting the reel and calender on no. 4 machine

Drier framing is double decked, box section. An automatic rope carrier system conveys the sheet through the driers, and a circulating oiling system provides automatic lubrication.

Calender Section: One seven roll, open-side stack with open side toward dry end of the machine; chilled iron rolls: bottom 44 in. diameter by 338 in. long; next to bottom 24 in. diameter by 338 in., other five rolls 20 in. diameter by 338 in.; three rolls are bored for steam.

Reel: Black-Clawson Autoflyte to handle 72 in. diameter rolls; pneumatically operated; cast iron reel drum 48 in. diameter by 336 in.; reel spools are 30 in. diameter by 343 in. balanced for 6000 f.p.m. An unwind stand with storage rail accommodates three 72 in. diameter rolls.

Winder: Black-Clawson Model 350; 2 drums 30 in. diameter by 336 in.; designed for 44 in. diameter rewound rolls, 6000 f.p.m.

GULF STATES

A $20,000,000 construction and modification program for Gulf States Paper's Tuscaloosa and Demopolis mills was announced today by company president Jack W. Warner.

Mr. Warner said the new investment represents the next phase in the continued growth and development of the company, Alabama's first major paper company. It is the third major expansion of Gulf States in the past decade. Production of the Tuscaloosa mill was increased in 1948, and the new Demopolis mill was opened last year.

Among the reasons Mr. Warner enumerated for beginning the expansion at this time was to expedite further the industrial development of West Alabama. He added the program would extend over the next three years and would be financed partially by a long-term loan from the New York Life Insurance Co. The total cost is expected to be approximately $20,000,000.

Part of the investment will be used to continue the construction of the Demopolis mill to make possible the production of a wide range of finished and semifinished paper and pulp products. These products will range from the fine, bleached pulp now being made there from southern pines and hardwoods, to fine, white papers.

"Plans for the Tuscaloosa plant," said Mr. Warner, "call for modifications and modernization to improve further the quality of the products now being manufactured, a quality now recognized as number one in the industry, and to increase the product line in order that Gulf States Paper may better serve its customers."

Completion of this program will make it possible for Gulf States Paper to utilize better the abundant supply of hardwood available to its manufacturing facilities.

Mr. Warner concluded by saying these plans represent a reaffirmation of Gulf States Paper's faith in the future of the South and the southern pulp and paper industry.

"New mill not a stinker" read a newspaper headline announcing yet another step up Gulf States Paper's ladder of steady progress, the opening of its Demopolis pulp mill. Behind that headline, the story goes back a few years to extensive studies and surveys which went into the search for a suitable site. By selecting Demopolis, present company executives reaffirmed the faith of Gulf States Paper's farsighted first president, the late H. E. Westervelt, in this section as best suited to the sulphate process of pulp manufacturing.

On Oct. 13, 1954, in announcing the company's puchase of a 1400-acre tract on which to build the multi-million dollar project, Jack Warner, then executive vice-president, said the property was bought, not only because of its abundant supply of both pulpwood and water, but also because Demopolis, is, as Mr. Westervelt said of Tuscaloosa, a "reasonable distance to markets, has a good labor supply of high intelligence, excellent schools and churches, and is in general a good place to live."

In September, 1955, the H. K. Ferguson Co. was assigned the job of designing and building a modern, highly-instrumented pulp mill. Ferguson, no stranger to Gulf States Paper, having worked on the Tuscaloosa expansion of 1948, immediately formed a design group. By May, 1956, actual construction began. Headed by Resident Manager Henry P. Halsell, and Ferguson's Project Manager Fred C. Patterson, a work force of 1200 men pushed erection of structural steel for the plant's major buildings, the digester, woodroom, bleach plant, pulp-drying room, boiler house, and storage and shipping building.

Construction was virtually finished by July, 1957. The Kamyr continuous digester, largest in existence, had been installed, making the plant one of the most modern of its kind anywhere. Also ready for use was the 21 million gallon per day water intake system, capable of supplying a city the size of Des Moines, Iowa.

A training program to acquaint hand-picked personnel with operational procedures of the plant destined to produce Alabama's newest industry, bleached kraft pulp for domestic and foreign markets, began with a welcome from top executives of the "Green Tree" family for the first classes' 55 members. Successive classes began January 16 and July 23, each course lasting from four to five weeks.

Before the mill went into operation, a team of 29 workers from the Tuscaloosa plant, 19 men from engineering operations, two from quality service, and eight pulp workers, volunteered to "check-out" the equipment.

On their return, Pulp Mill Superintendent Malcolm Comer had a letter of thanks and a gift for each man from Henry Halsell containing a shirt similar to ones worn by regular Demopolis crews.

On Aug. 6, 1957, the distinction of delivering the new mill's first load of pulpwood went to Ray Griffin, Demopolis dealer, whose father delivered the Tuscaloosa plant's first load in 1929.

As more men completed training and joined the permanent force, the mill slipped into high gear. Operation began in August, and pulp production climbed to the expected peak and on beyond. The crews worked hard getting "bugs" out of machinery, welding men of varied technical backgrounds into interdependent teams, adapting to new policies and supervision, and coping with the problems created by the severest winter of this century.

The company's belief that Alabama money should be spent in Alabama is pouring millions of dollars annually into the state's business and agriculture. To illustrate graphically the far-reaching effects a new industry can have on a town, the first payroll was made with two dollar bills for easy tracing.

Available for helpful advice, foresters employed by Gulf States Paper are proving a boon to farmers and landowners

seeking ways of turning forest land into a stable income-producing crop.

After countless man hours of deliberation and discussion, the Demopolis pulp mill's first labor agreement was signed Dec. 20, 1957, by the company, and the United Papermakers and Paperworkers, AFL-CIO. Covering the 173 employees represented by Local 719, the contract called for two to four dollars an hour, the highest wage rates in the industry, made necessary by the highly specialized nature of the work.

Demopolis plant employees make good use of the two three-week trips the company's boat, the *E-Z Kraft*, makes there each summer. Seldom are its decks empty of people having a good time.

—From *The News Bag*, Gulf States Paper Corp., Tuscaloosa, Ala., Oct., 1958.

Continental Can

William H. Caddoo, general manager of the Gair Boxboard and Folding Carton Division of Continental Can Co., has been elected a vice-president of the company, Gen. Lucius D. Clay, chairman of the board, announced.

A new and modern corrugated container research laboratory, fitted out with the latest testing equipment, has been put into operation at Van Wert, Ohio, by the Fibre Drum & Corrugated Box Division of Continental Can Co.

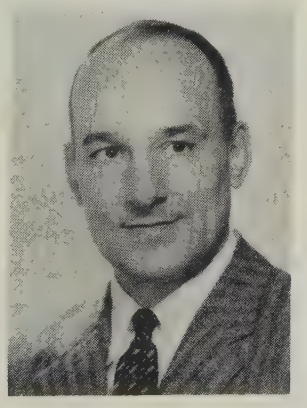
Supplementing the division's present fiber drum research facility, the new corrugated container laboratory has been constructed as a building within a building, eliminating the influence of outside atmospheric conditions which would hamper maintenance of the desired test atmosphere of 50% R.H. and 73°F.

Directing operations at the new research facility, is C. H. Root, who recently joined Continental Can as manager of corrugated research. Mr. Root came to Continental Can from the Institute of Paper Chemistry at Appleton, Wis., where he worked for 23 years—first in the physics department on special instrumentation, including standardization of brightness testers and color systems, and later in the container section of the Institute where he set up a system of standardization of physical testers used in container research.

The new corrugated container research laboratory, which will be Mr. Root's headquarters, has in it a preconditioning room which sustains control conditions of less than 35% humidity and a high temperature humidity room where controlled relative humidity up to 95% and temperatures up to 150°F. may be achieved. Low temperature testing has been provided for with a walk-in refrigerator which can hold temperatures down to as low as −30°F.

Other modern equipment in the laboratory includes: a 90 in. motor driven sample maker, Conbur tester, 36 by 48 in. compression tester, 7 ft. revolving drum tester, 1000 lb. vibration tester, drop tester, and miscellaneous testing instruments such as mullen, beach, tear, concora, and impact testers.

W. H. Caddoo Continental Can Co.



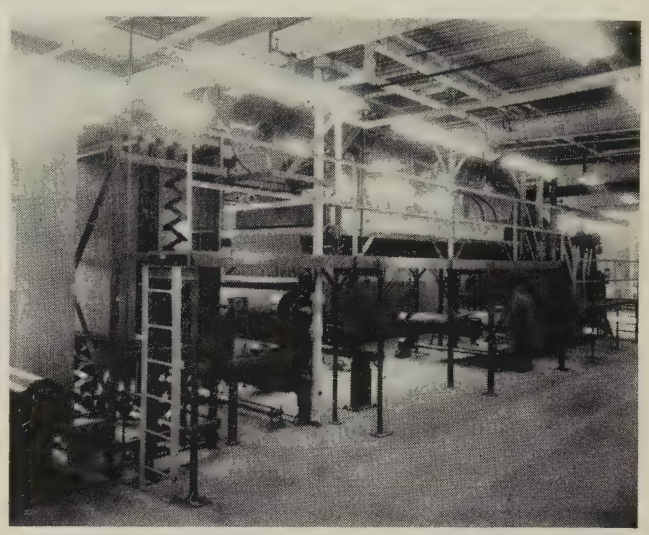
C. H. Root, Continental Can Co.

Ford

Ford Motor Co. announces it has completed installation of a plastisol coating line at their Mount Clemens, Mich., chemical products plant. This machine line was built to the specifications of the Ford Motor Co. and engineered by The Black-Clawson, Dilts Division, of Fulton, N. Y.

The equipment will produce coated webs of paper or fabric, 62 in. web width with organisols, plastisols, and other types of coating. The machine can also produce unsupported cast film.

The machine line includes a two position fabric unwind, Mt. Hope scray, guiders, paper unwind, coater, Dawson Pre-fuser and Vapor-fuser, cooling drums, stripping section, compensator, paper winder, and two position fabric winder.



This plastisol coating line in the new Mt. Clemens, Mich., plant of the Ford Motor Co. was engineered and built to Ford specifications by The Black-Clawson Co., Dilts Division. It coats webs 62 in. wide of various materials in the production of automotive interior trim products

The coater is designed for application by supported and unsupported knife, gravure, roll, and print coating methods. The drive is a sectional electric U. S. Motors Varidyne system. The entire installation utilizes centrallized control cabinets and explosionproof equipment.

The new Ford Mount Clemens plant will be in full production late this year producing automotive interior trim products.

Clupak

Licensing agreements to manufacture stretchable paper have been signed by two of the nation's leading producers, it has been announced by Gerald E. Amerman, president of Clupak, Inc., which owns the trademark Clupak and patents on the process and product.

The first license was signed by International Paper Co., the country's largest producer of paper and paperboard. This company will install its first extensible papermaking unit on a large kraft paper machine at its Camden, Ark., mill.

The other signer is West Virginia Pulp and Paper Co., which has one extensible paper unit operating on a kraft machine at its Charleston, S. C., mill and has a second unit ready for installation on another kraft machine at this same location.

Clupak, Inc., is equally and jointly owned by Cluett, Peabody & Co., Inc., and West Virginia Pulp and Paper Co.

The license agreements were signed by Mr. Amerman for Clupak, Inc., and by Stuart Kay, executive vice-president, International Paper Co., and by David L. Luke, president of West Virginia Pulp and Paper Co., for their respective companies.

"Just as soon as licensing is fully underway in the United States," Mr. Amerman said, "it is the intention of Clupak, Inc., to initiate a licensing program extending to all the paper-producing countries of the world."

Clupak paper is made by a mechanical process which imparts stretch to the paper without affecting its normal surface smoothness. The paper is made from regular wood pulp on a conventional paper machine equipped with extensible paper-making units, which are part of an in-line operation.

The built-in stretch, which can be controlled with precision, gives Clupak paper greater toughness and makes it able to withstand considerably more impact than conventional paper.

The process is the invention of Sanford L. Cluett, vice-president of Cluett, Peabody & Co., Inc., who is also the inventor of the compressive shrinkage process behind the famous "Sanforized" trademark appearing on cotton fabrics. Commercial development of the process was accomplished by West Virginia Pulp and Paper Co.

Through its technicians and engineers, Clupak, Inc., will provide licensees with technical assistance in machine design and installation, as well as research and product development data.

Formica

A new flakeboard plant, costing about $5,500,000 and capable of producing 40,000,000 sq. ft. a year, was opened formally November 14 at Farmville, N. C., by the Formica Corp. The flakeboard will be used as a base for laminated plastics such as Formica. It also will be offered for use in furniture, cabinet doors, flush door faces, sandwich panels, and decorative wall paneling. Company officials said it also may be used soon for sheathing in walls and subflooring.

The new plant, about 65 miles northeast of Raleigh, will use a process that Formica developed through considerable research. It will use green pine timber instead of the wood waste that forms most particle board.

The product will have a breaking strength of 3500 p.s.i., compared with 3000 p.s.i. for conventional flakeboard, the company said. Formica, a subsidiary of the American Cyanamid Co., also said its processing could be varied to meet specific requirements. Sheet sizes can be as large as 6 by 12 ft. in thicknesses of $^1/_4$ to $1^1/_4$ in.

W.M.V.

In order to encourage good organization of data, systematic search for facts, and lucid presentation of conclusions and information, the Kalamazoo Valley Section of TAPPI has established an award to be known as the Kalamazoo Valley TAPPI Research Award.

Any full-time student at Western Michigan University enrolled in the curricula of paper technology and participating in the course "Research Problems in Pulp and Paper" is eligible for this award.

Selections for this award will be made by an Awards Committee at a time and place to be announced. Oral presentations will be given to the committee, and winners of the awards will present a synopsis of their theses to the joint TAPPI-APPMSA dinner meeting known as Recognition Night, on May 14, 1959.

The following factors will be considered in the selection of the awards: preparation, oral presentation, organization, poise, interest, visual aids, quality of research notebook and literature survey.

The award for 1958–59 will be: first prize $100.00, second prize $60.00, and third prize $40.00.

For the fall semester of 1958 there are 110 students enrolled in the department of paper technology. 219 class cards have been issued. These are in addition to enrollees in field service courses.

For the first time, the department has enrolled a woman student who plans to take the four-year technical option in the department.

Option III, for training for sales positions in the paper industry, being offered for the first time this fall, has nine students enrolled in it.

Two senior paper technology students at Western Michigan University will continue their studies next year at The Institute of Paper Chemistry, Appleton, Wis., according to A. H. Nadelman, head of the paper technology department.

As ranking seniors academically they have been granted very attractive fellowships for their first year of graduate study.

They are Thomas C. Elias, son of Mr. and Mrs. Robert T. Elias, Lawrence Rd., Potsdam, N. Y., and Earl W. Malcolm, son of Mr. and Mrs. Roy L. Malcolm, 1316 14th Ave., Menominee, Mich.

Their enrollment next fall will bring to five the number of W.M.U. paper graduates studying at the Institute.

Syracuse

Graduate fellowships for 1959–60 are being offered by the State University, College of Forestry at Syracuse University. Research fellowships are available carrying stipends beginning at $2000. The college also expects to offer 24 assistantships for the 1959–60 college year. Stipends vary from about $1400 to $1600 on a nine month's basis.

Tuition waivers for deserving undergraduate out-of-state students are also available. Applications for the above may be obtained from the Associate Dean for Graduate Studies, State University College of Forestry of Syracuse University, Syracuse 10, N. Y.

North Carolina State

The Pulp and Paper Technology program in the North Carolina State College School of Forestry is recognized by the

Dean of Students Richard W. Ivers of Lowell Technological Institute congratulates winners of $100 scholarships in paper engineering in memory of Geoffrey R. Broughton, left to right: Bernard Coyle of Salem, '61, Frank Zichelle of Fitchburg, '60, and Frank L. Rawling of Lowell, '59, as Prof. John Lewis, paper engineering department head, far right, looks on. Industrial sponsors of the scholarships are American Writing Paper Co., Holyoke; Byron Weston Co., Dalton; Carter, Rice, Storrs & Bement Co., Boston; Champion-International Division of Oxford Paper Co., Lawrence; Chemical Paper Mfg. Co., Holyoke; Continental Can Co., Robert Gair Paper Products Division, New York; Crocker, Burbank & Co., Ass'n., Fitchburg; Fitchburg Paper Co., Fitchburg; Monadnock Paper Co., Bennington, N. H.; Strathmore Paper Co., West Springfield; Tileston & Hollingsworth Co., Boston; and Triangle Foundation of the Nashua Corp., Nashua, N. H.

Southern Regional Education Board as the regionally approved program in this field in the 16-state area.

Union Associates

Purchase of the Union Machine Co. and Union Screen Plate Co. of Fitchburg, Mass., has been announced by a new corporation, Union Associates, Inc., also of Fitchburg. Final arrangements in connection with the sale are being made and it is expected that physical control will change hands within three to four weeks. Negotiations for the sale were carried out with the Trust Dept. of the Safety Fund National Bank of Fitchburg, in connection with the settlement of an estate which held controlling interests in both companies.

The new corporation has been organized specifically for the purpose of this purchase. Incorporators include Bigelow Crocker, Jr. of Crocker, Burbank & Co., Assen., William S. Kemp, Jr. of Crocker, Burbank Papers Inc., Francis M. Rhoten of Hope Rubber Co., Inc., Samuel T. Orton, Jr. of Orton Corp. and others, also engaged in business in the Fitchburg area. Mr. Orton will be president and will undertake the active management of the business.

The Union Machine Co., was founded in 1868 and has been active for many years in the manufacture of papermaking machinery and various other types of machinery for local industry. The Union Screen Plate Co. was founded in 1902 to continue the manufacture of screen plates for the paper industry which had formerly been made by Union Machine Co. Both are well known in the paper industry of the United States and in addition have furnished equipment, particularly screen plates, in many foreign countries over the years. The Orton Corp. was founded in 1951 as a sales agency for paper mill equipment and has been active primarily in the Northeastern part of the United States. It will become a subsidiary of Union Associates, Inc. and will continue its established business under the management of Douglas P. Newcombe of Westminster, Mass. Prior to joining Orton Corp., 5 years ago, Mr. Newcombe was Plant Engineer for Crocker, Burbank & Co., Assen.

Plans for the future are necessarily incomplete as yet, but the purpose of the new management will be to continue the businesses in the general area of past activity with strong emphasis on steady growth through improvement of facilities and products.

Huyck Felt Co., Rensselaer, N. Y., recently conducted its eleventh felt workshop. Graduates, seated clockwise at table at left are: F. E. Ferrige, Thilmany Pulp and Paper Co., Kaukauna, Wis.; Roger Traxler, Marinette Paper Co., Ft. Edward, N. Y.; Donald Finnegan, Great Northern Paper Co., East Millinocket, Me.; William Bowen, Scott Paper Co., Chester, Pa.; Charles Rothwell, Rogers Corp., Rogers, Conn.; L. R. Giersch, Crown Zellerbach Corp., Los Angeles, Calif.; J. W. Gray, Jr., Downingtown Paper Co., Downingtown, Pa.; William Clark, International Paper Co., Corinth, N. Y.; S. D. Hodge, Bloomer Brothers Co., Newark, N. Y. Around the righthand table (starting at front, inside) are: Stanley Backer, professor at M. I. T., Cambridge, Mass.; Webster Hilton, Downingtown Paper Co., Downingtown, Pa.; Alex Wazlak, Marcalus Manufacturing Co., East Patterson, N. J.; John Stefonik, Rhinelander Paper Co., Rhinelander, Wis.; Welton Davis, West Virginia Pulp and Paper Co., Luke, Md.; J. W. Mengel, Eastman Kodak Co., Rochester, N. Y.; Frank Kichefski, Rhinelander Paper Co., Rhinelander, Wis.; Romeo Cormier, Gardiner Paper Mills, Gardiner, Me. and Louis Orbaker, Bloomer Brothers, Newark, N. Y. Hans Dirzuweit, Huyck's senior research engineer, directed the discussion. A total of 238 papermakers have attended Huyck's felt workshop sessions. The 1959 schedule will be announced shortly

ADM

Archer-Daniels-Midland Co. has announced that its Industrial Cereals Department will handle the marketing of bentonite to the paper industry.

Bentonite is a clay with exceptional absorption and adhesive properties that make it ideal for pulp refining, by-product recovery, and papermaking applications.

ADM operates some 25,000 acres of prime, open pit bentonite mining property in Wyoming. The company's mines there also supply bentonite to the taconite industry, which uses the clay to bond the iron dust recovered from taconite into pellets suitable for blast furnace operations.

Paul Werler, manager of ADM's Industrial Cereals Department, said bentonite is important in overcoming one of the paper industry's most serious problems, the pitch in some pulp woods. It also helps impart smoothness and gloss in paper coatings and in keeping other ingredients in suspension. Bentonite is recommended for dispersing asphalt and deinking newsprint and rag stock. It also recovers by-products of the papermaking process.

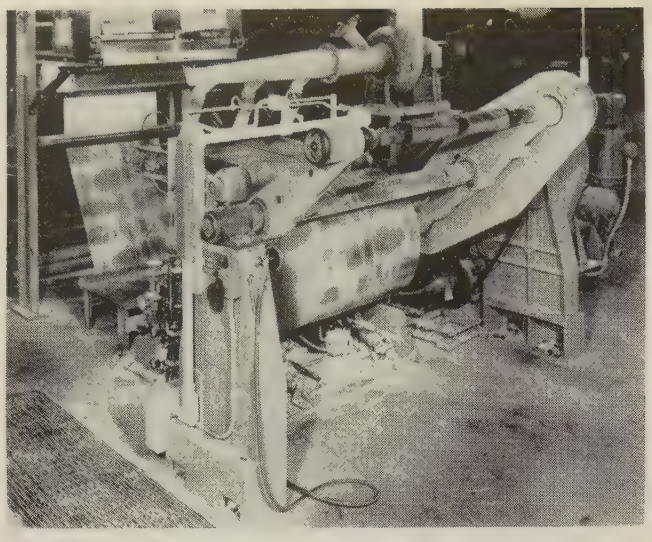
Valley Iron Works

The Valley Iron Works Co. of Appleton, Wis., announces completion of reorganization and assignment of personnel at the executive level.

R. A. Peterson continues as president and general manager.

Other assignments are: W. A. Homes, assistant general manager; Talbot Peterson, secretary; Willard C. Notbohm, assistant executive vice-president; Gregory A. Schulte, treasurer; Paul Boronow, vice-president of pulp and paper mill equipment sales; W. K. Kolb, vice-president in charge of industrial sales; George E. Reynolds, chief engineer; Carl G.

W. D. Stroud, district sales manager, Huyck Felt Co. (left) and Professor Lyle C. Jenness, head of chemical engineering, University of Maine, discuss felts presented by Huyck to the College of Engineering earlier this year. The felts clothe the first and second press positions of the new experimental paper machine which will be operated by Pulp and Paper Foundation Scholarship recipients



A Dilts Model 20 winder, built by The Black-Clawson Co., Dilts Division, Fulton, N. Y., recently went into operation on a 10-color perfecting rotary offset printing press at the Safran Printing Co., Detroit, Mich. A unique installation in many of its features, the new winder provides center winding with dancer roll control for constant tension over a build-up range of 11 1/2 to 1. The unit delivers 40-in. diam. finished rolls for color page inserts to newspapers. The winder allows automatic roll change at full speed of 700 f.p.m. Provision is made for slitting the sheet into two webs with edge trim and center cut trim removed. The core shafts of this unit are air expanded, allowing rapid removal of the shafts

Malmberg, works manager; and Helm C. Hussner, general superintendent.

In addition, Paul Boronow announces that Richard U. Temple, Raymond A. Bennett, Harold A. Norseen, and William S. Mounts are to be district sales managers.

Fischer & Porter

Fischer & Porter has just published a 52-page catalog on process instruments available for quick shipment. Catalog 2 covers indicators, transmitters, recorders and controllers for flow, pressure, temperature, density, viscosity, and consistency.

Copies of the new catalog are available on request from Fischer & Porter Co., 941 Jacksonville Rd., Hatboro, Pa.

Custom Scientific

The new C.S.I. Catalog No. 59, containing descriptions of testers and equipment used in the paper industry, has been issued by Custom Scientific Instruments, Inc., Kearny, N. J.

Pennsalt

Pennsalt's Technical Bulletin no. H-2021, "Automatic Continuous Manufacture of Hypochlorite Solutions," is available from Pennsalt Chemicals Corp., 2901 Taylor Way, Tacoma 2, Wash.

Allis-Chalmers

Products of Allis-Chalmers Manufacturing Co. are described in their new booklet "59 Ideas for Modernization in '59." Copies are available from the company at Box 512, Milwaukee 1, Wis.

Torrington

Torrington Catalog No. 258 describing Torrington's line of spherical roller bearings is available from the Torrington Co., South Bend 21, Ind.

B&W

The Tubular Products Division of the Babcock & Wilcox Co. has issued a new technical data folder on the family of 18-8 stainless steel. Copies of the folder, identified as TDC-190, are available through the division general offices at Beaver Falls, Pa.

Dewey & Almy

Paper coating chemicals are described in Dewey & Almy's Bulletin entitled "Darex Paper Coatings Emulsions." It is available from Dewey & Almy Chemical Division, W. R. Grace & Co., 62 Whittemore Ave., Cambridge 40, Mass.

Du Pont

"Quilon" is the title of a new booklet describing this chrome complex for use in the paper industry. The chemical is used to provide water repellency, improve wet strength and size, and release characteristics to paper products. Copies may be obtained from Grasselli Chemicals Department—D-4012A, E. I. du Pont de Nemours & Co., Inc., Wilmington 98, Del.

Addition of small amounts of a Du Pont chemical to pulp in the beater or pulper will minimize and often eliminate graniting caused by direct dyes, according to tests conducted by Du Pont paper chemists.

The paper dyeing problem, evidenced by a few deeply dyed fibers, results from absorption of larger amounts of dye by certain fibers in the pulp mixture. It is most common with direct dyes in the violet, blue, green, and black shade range. Adding 2 lb. of Du Pont Retarder LAN to one ton of pulp and blending it well before addition of the dye and other ingredients overcomes the graniting.

Tests indicate Du Pont Retarder LAN causes no foaming difficulties and helps improve the over-all quality of the paper. Best results are attained when the pulp mixture is adjusted to a pH of 6 or higher prior to addition of the retarder.

Shown above upon completion of landscaping is the new international headquarters of Dorr-Oliver Inc. on Havemeyer Lane in Stamford, Conn. The new building, occupied by the company in June of this year provides 120,000 sq. ft. of office space for approximately 500 executive, administrative, and financial staff, sales department, and a majority of the company's technical divisions. Located on a 20-acre tract, the building is essentially a two-story hollow square surrounding a central landscaped court. Though simple and functional in design, the contemporary structure incorporates a number of new and unusual architectural features which provide an atmosphere representative of the company's international operations

Sandoz

"Sandopan DTC for Pulp Bleaching" is a new technical bulletin offered by Sandoz, Inc. It reports on use of a cryptoanionic synthetic detergent in a multistage chlorine bleaching cycle. Copies may be obtained from the Sandoz, Inc., Paper Dept., New York 13, N. Y., or at local Sandoz offices.

Fuller

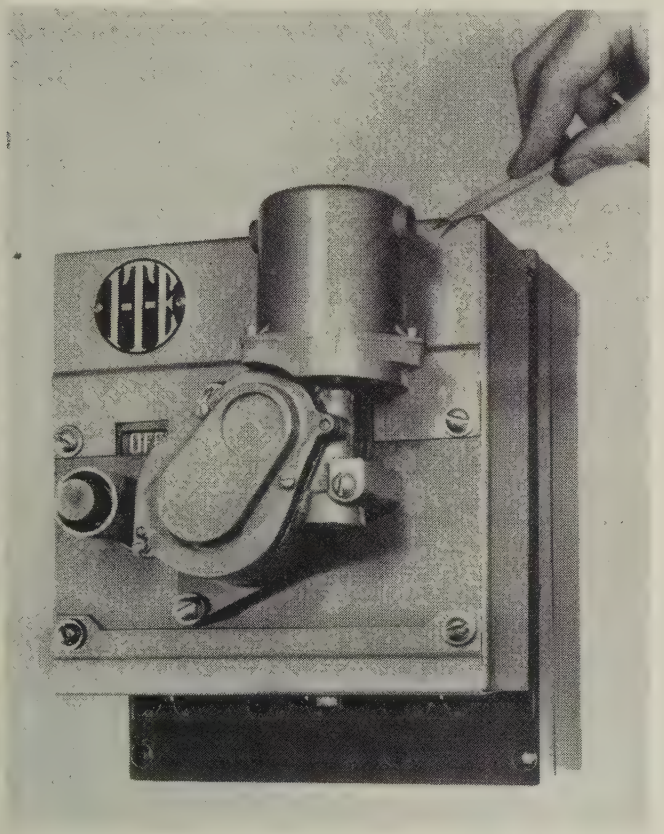
Problems involved with the handling of salt cake are exhaustively treated in Fact File ER-26-1 offered by Fuller Co., Catasauqua, Pa., entitled "Properties, Storage and Conveying of Salt Cake."

Cleveland Crane

Aluminum inverted-Y conductor systems developed by The Cleveland Crane & Engineering Co., Wickliffe, Ohio, are described in their Electrification Booklet No. 1.

I-T-E

A versatile motor-operated mechanism which makes possible both remote control and automatic transfer systems using molded-case circuit breakers, has been introduced by the I-T-E Circuit Breaker Co., Philadelphia.



I-T-E circuit breaker

Further information may be obtained from I-T-E Circuit Breaker Co., 1900 Hamilton St., Philadelphia 30, Pa.

A new bulletin, No. 2804-1A, describing in detail its line of 4160 v. metal-clad switchgear has been published by I-T-E Circuit Breaker Co.

National Aluminate

Nalcoag, a colloidal silica offered as an aqueous suspension of 15, 30, or 35% silica has recently been made available by National Aluminate Corp. The product is used as an antiskid treatment for all types of paper containers. The company also expects it to prove useful as an additive for strengthening paper and a treatment for improving soil resistance, wettability, ink absorption, and other surface characteristics of paper products.

New Nalco Bulletin K5 describes the physical and chemical properties of Nalcoag and lists present and potential uses.

"Water Conditioning with Nalcite Ion Exchangers" is a new 60-page handbook explaining the ion exchange method of water conditioning. Copies are available from National Aluminate Corp., Ion Exchange Division, 6197 West 66th Place, Chicago 38, Ill.

John Waldron

John Waldron Corp., subsidiary of Midland-Ross Corp., has completed the preparation of its new General Catalog No. 10, entitled "Web Process Engineering." A copy of the catalog may be obtained by directing your request to John Waldron Corp., Subsidiary of Midland-Ross Corp., P. O. Box 791, New Brunswick, N. J.

Penick & Ford

O. H. Tousey, vice-president in charge of sales for Penick & Ford, has announced the appointment of Fran Ware as sales representative in the Michigan-Wisconsin area.

Penick and Ford, Ltd., Inc., industrial processors of corn products, have just released a revised catalog titled, "The Penford Gums." Directed to the textile and paper industries, its text is both technical and descriptive with valuable information provided on the characteristics, properties, and many uses of the various gums.

The Penford Gums catalog is available on request by writing to Penick and Ford, Ltd., Inc., 750 Third Ave., New York 17, N. Y., or from your Penick and Ford representative.

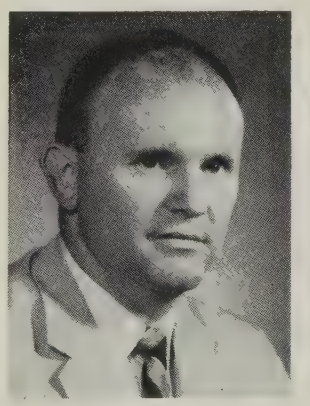
Frank Ware, Penick & Ford, Ltd., Inc.

Chromium Corp.

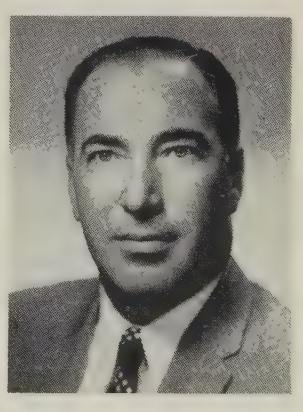
Appointments to sales territories in the midwest are announced by Chromium Corp. of America.

Ronald D. Pahlow represents the corporation in the states of Wisconsin, Minnesota, and the upper peninsula of Michigan. He has covered portions of this territory in the past and will call primarily upon industries associated with the manufacture of pulp and paper.

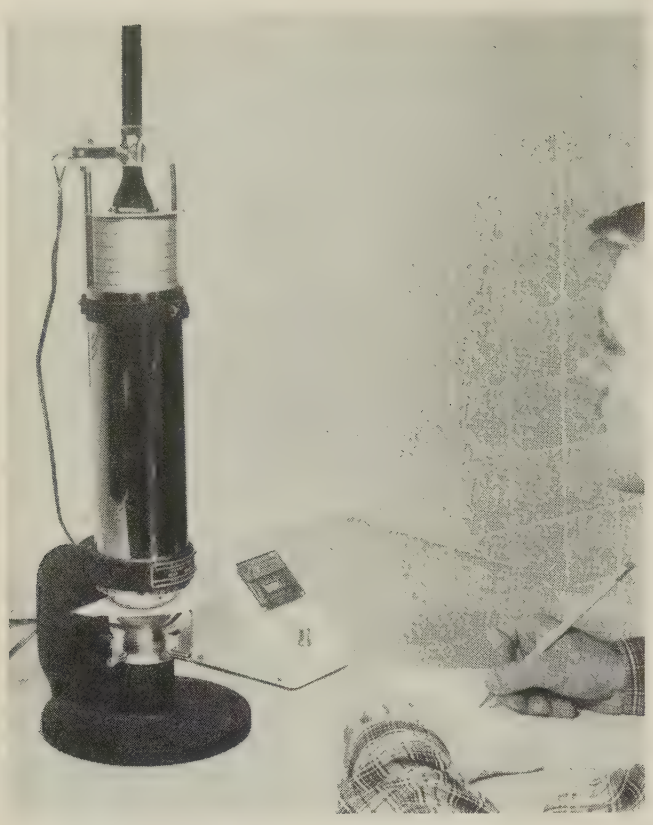
Howard K. Wagner will cover the states of Michigan, Indiana, and Ohio. Service to the pulp and paper industry will be a primary activity.



R. D. Pahlow, Chromium Corp. of America



H. K. Wagner, Chromium Corp. of America



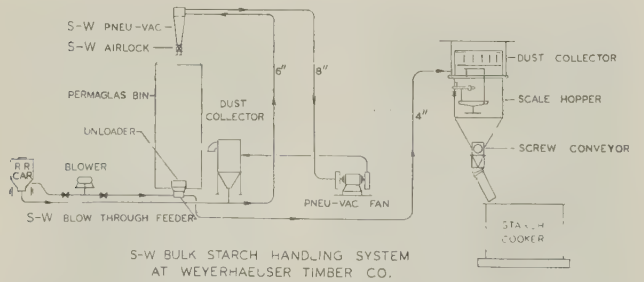
Gurley densometer with automatic timing

GURLEY

The Gurley Improved Densometer is now available with an automatic timing device, it has been announced by W. & L. E. Gurley's Industrial Division. For full details on this and other models of the Gurley Densometer, as well as the complete line of Gurley testing instruments, write W. & L. E. Gurley, Troy, N. Y. Ask for Bulletin 1400.

SPROUT-WALDRON

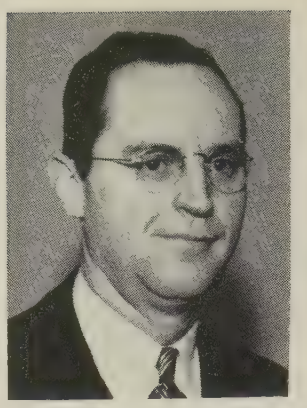
Lower cost, less contamination, cleaner and safer working conditions are among the advantages cited by the Pulp Division, Weyerhaeuser Timber Co., Springfield, Ore., in describing its new bulk starch conveying and storage system, designed and engineered by Sprout, Waldron & Co., Inc. The system is used for unloading bulk starch from hopper bottom cars as well as for taking the starch to bulk storage and from there to cooking vats in weighed quantities. According to the engineers at Weyerhaeuser, the new method uses pushbuttons and automatic controls to take the place of back-breaking toil and guesswork.



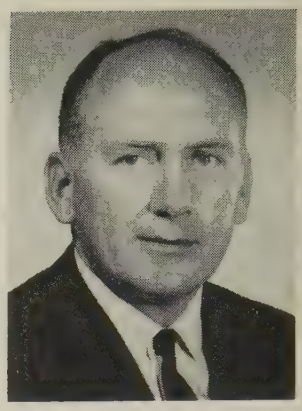
S-W BULK STARCH HANDLING SYSTEM AT WEYERHAEUSER TIMBER CO.

Weyerhaeuser unloads an average of one 50 ton Arislide car per week. Unloading time, including hookup, changing hoppers, etc. is between seven and eight hours with the actual unloading rate set at 10 tons per hour. Prior to using Airslide cars, ordinary hopper cars were used. These required continuous rodding to get the starch to unload and resulted in unloading times of nearly double that which is now secured through the use of Airslide cars.

Key equipment in the bulk unloading method are the Sprout-Waldron negative pressure system which unloads the Airslide cars and delivers the starch into the glass-lined storage bins; and the Sprout-Waldron positive pressure system which actuates the car and conveys the starch from the bin unloader to the scale hopper.



H. C. Guy, Koppers Co., Inc.



C. C. Hendricks, Bauer Bros. Co.

KOPPERS

Hubert C. Guy has been named technical director of coatings in the marketing department of the Plastics Division, Koppers, Co., Inc.

BAUER

Bauer Bros. Co., Springfield, Ohio, has announced the addition of Crockett Carl Hendricks to its southern sales division. Mr. Hendricks has wide experience in the pulp and paper industry. He was formerly with Albany Felt Co., Albany, N. Y.

MT. HOPE

The engineers who plan and design—and service—Mount Hope rolls get around quite a bit, spending a lot of time with the people who use their equipment to make better paper—faster, and at lower cost. Out of this close contact with practical papermaking came the conclusion that a number of paper mills looked upon Mount Hope rolls as being good for one or two specialized jobs, but were not using the rolls for other important production operations.

So a few months ago Mount Hope did something about it. They planned and started the preparation of a series of "Technical Bulletins" designed to show the production man who was using Mount Hope rolls on only one or two applications how he could use them in other ways, to speed output and cut costs.

The first bulletin gave some brief, informative facts on the advantages of Mount Hope rolls ahead of, or within, the drying section, to eliminate wrinkles, soft spots, and baggy edges. Mount Hope was pleansantly surprised to get a number of letters from paper men who liked the idea, along with requests for additional copies of the bulletins for distribution to each production man in a plant.

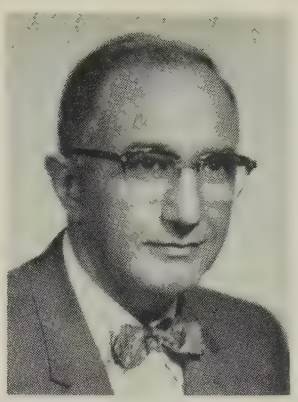
The bulletin series to date includes "Bow Setting," "Wraps and Bows," and applications to driers, size press, calenders and slitters and cutters. Others are in preparation. Anyone interested may get copies of the entire series by writing Mount Hope Machinery Co., 15 Fifth St., Taunton, Mass.

PATTON

Egon Kornicer has been named assistant chief engineer of the Patton Manufacturing Co., paper machinery builders of Springfield, Ohio. Mr. Kornicer joined Patton in the fall of 1957 as project engineer.

Egon Kornicer, Patton Manufacturing Co.

W. R. Gerschon, John W. Bolton & Sons, Inc.



P. J. Jerardi, Beloit Iron Works

E. N. Glauner, Jr., Beloit Iron Works

Bolton-Emerson

John W. Bolton & Sons, Inc., announces that Wilfried R. Gerschon has joined its industrial engineering staff.

Howard W. Edminster has been appointed sales engineer by John W. Bolton & Sons, Inc., and the Emerson Manufacturing Co., Division, for a southeastern territory, was announced by S. E. Crocker, Jr., manager, Southern Region.

John W. Bolton & Sons, Inc., Lawrence, Mass., has recently installed an automatic, electrically controlled, bell type tempering furnace for stress relieving, annealing, tempering and drawing machine knives up to 48 in. in length.

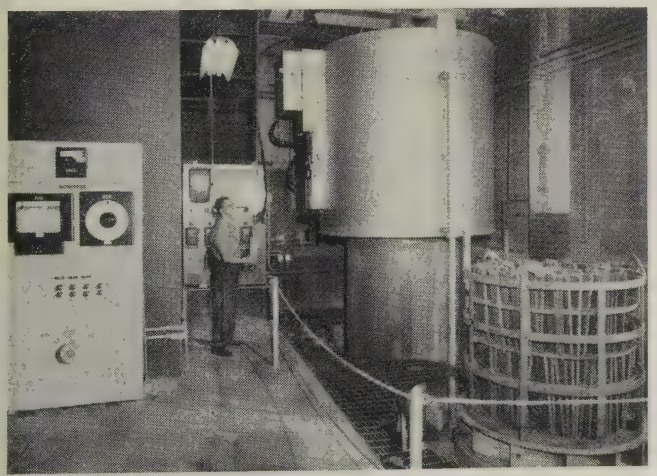
Controls for the new unit were designed specifically for Bolton's requirements. Heat is held to accurate pre-set temperatures and is continuously monitored by recording instrumentation. The cooling cycle is similarly controlled to give the knives a slow, uniform return to room temperature.

By such precision control over the time and temperatures of the complete heating and cooling cycles, and by maintaining detailed data on each knife load, absolute uniformity and duplication of heat treating can be guaranteed. The new facility increases many times the number of knives that can be tempered simultaneously.

Bolton's new electric furnace is unique in its operation compared to conventional types. The furnace heats two chambers alternately, each with over 100,000 cu. in. capacity. Knives are placed in specially designed wire baskets containing spacer units to prevent any contact between them. This method assures free circulation of air surrounding all knives.

After the wire baskets are loaded with knives, they are placed on the hearth. A hood is lowered over the racks providing total enclosure. At this point the furnace is lowered over the hood. Air is recirculated inside the hood by a fan located in the hearth and temperature of the load is recorded and controlled continuously.

A new eight-page bulletin describing both their carbon and high speed paper knives has just been published by John W. Bolton & Sons, Inc. Request Paper Knife Bulletin No. PK 558, John W. Bolton & Sons, Inc., Lawrence, Mass.



View of new automatically controlled electric heat treating installation at John W. Bolton & Sons Inc., showing furnace being lowered over the hood. Within the hood is a specially designed wire basket for holding knives like the one shown at right resting on the hearth. Instrument panel at left provides instant and continuous monitoring of automatically controlled heating and cooling cycles

Beloit

P. J. "Pete" Jerardi has recently become associated with Beloit Iron Works. Mr. Jerardi has had extensive experience in the field of papermaking machinery and is returning to the paper industry after several years association with a manufacturer of heavy machinery. Mr. Jerardi plans to make his headquarters at Hamilton, Ohio.

Emerson N. Glauner, Jr. has joined the sales department of Beloit Iron Works, Beloit, Wis. Mr. Glauner has had wide experience in the paper industry as well as in the field of papermaking machinery with particular respect to cylinder board machines. Mr. Glauner and his family are now making their home in Beloit.

Appleton Woolen

How to use photographic work sampling to lower labor costs, improve quality, and increase production is explained in an article now available from Appleton Woolen Mills, papermakers' felt manufacturer.

The photographic work sampling case history, authored by industrial engineer Robert L. Barlament, is reprinted from *Textile World*. In addition to describing this new cost cutting technique in detail, the article also indicates how other companies, such as paper manufacturers, can apply this approach to own production problems.

For a copy of "Photographic Work Sampling—A New Cost Control Technique," write: Promotion Dept., Appleton Woolen Mills, Appleton, Wis.

Sheffield

A new high-speed, variable-area Porosimeter® instrument for testing a wide range of paper porosities quickly and accurately is available from The Sheffield Corp., Dayton 1, Ohio, subsidiary of Bendix Aviation Corp.

Porosity is determined by measuring the rate controlled air flows through the test area. The position of a small float in a column of air in the Precisionaire® instrument indicates the degree of porosity.

Shown at left is Sheffield's new high-speed variable-area Porosimeter® gage that uses different size test areas in measuring the porosity of paper. At the right is the Smoothchek® paper smoothness tester. The Precision-aire® instrument is used interchangeably with the two gages

The Porosimeter® is supplied with four sets of rubber seals, each having a different orifice size to permit various size test areas. Dense, relatively nonporous papers require a larger size test area than the more porous papers such as those up to the filter range.

This flexibility in test area size is said to permit more realistic appraisal of product quality. It is an exclusive feature with the Sheffield instrument.

B-C

A wide range of new developments in the coating of paper and board were demonstrated and discussed at a Black-Clawson interdivisional conference recently held at the Dilts Division, Fulton, N. Y. More than 50 members of management, sales engineers, and design engineers of Dilts and the Paper Machine Division, Watertown, N. Y., participated in the lecture sessions and laboratory demonstrations of the conference.

The Black-Clawson Co.'s extensive research and development program is centered at the Dilts Division coating laboratory and pilot plant. The program has produced the most complete line of coating machinery available, company officials state.

The most recent development in the line is the Flexiblade trailing blade type coater which the conference members viewed in semicommercial operation.

Lectures and exhibits were also devoted to the latest improvements in the Warren-Dilts air doctor coater and the Black-Clawson metering bar coaters for board machine coating application. A commercial metering bar unit, being readied for shipment in the Dilts shop, was shown to the group to demonstrate important new features of this product.

The conference was directed by Robert J. Jacobs, general manager of the Dilts Division. At a luncheon gathering of the group, Robert F. Vokes, administrative vice-president, outlined recent research and development achievements of all divisions of the Black-Clawson Co.

Roots-Connersville

Roots-Connersville Blower, Division of Dresser Industries, Inc., Connersville, Ind., is establishing a new district office at 3166 Maple Drive, N. E., Atlanta 5, Ga. The manager of the new office will be Paul E. Johnson, effective immediately.

Roots-Connersville is also establishing a new district sales office at 5120 Pacific Blvd., Los Angeles 58, Calif. According to the announcement made by Glenn H. Crocker, general sales manager, the manager of the new office will be H. W. Newsome, effective immediately.

Stevens

Charles R. Stevens, Inc., Maumee, Ohio, having undertaken a long range program of supplying complete paper mill finishing equipment, held their first annual exhibition at their plant on November 13.

The exhibit was attended by about 100 representatives of over 40 paper mills throughout the industry. Encouragingly noticeable was the fact that all attending were those directly concerned with finishing.

The groundwork for this program was laid at the 43rd TAPPI Annual Meeting in New York last February when "Finishing, The Orphan of the Paper Industry" was presented by Charles Stevens, president of the firm.

At this exhibit of 1959 equipment, Stevens introduced a completely new line including two continuous roll stands, a two-color surface decorating rotogravure press and the Stevens-Finch Pruyn Air-Flight paper handling system as major machines. Many finishing accessory items were also shown. Included in this group was the new Stevens Redi-Lift air or hydraulic operated roll loader, air operated shaftless unwind stand, the Stevens counters and markers, the Stevens-Howard Smith load levellers, aluminum clamp-type core chucks, nylon bearings, and the new type Stevens Table Air Jets were among the many other finishing accessories.

Mixco

A six-page folder describing the complete laboratory facilities now available to the industry at Mixing Equipment Co. is available free from the company. A special section is devoted to the new hazardous materials laboratory.

The folder outlines the pilot-plant mixing operations of the hazardous materials laboratory and describes the unique uses of the new continuous multistage contactor. General information is given on industrial mixing research and studies at Mixco.

For free copies write to: Mixing Equipment Company, Inc., 158 Mt. Read Blvd., R chester, N. Y. In Canada write to: Greey Mixing Equipment, Ltd., 100 Miranda Ave. Toronto 19, Ont.

OBITUARY

Ralph M. Kingsbury

Ralph M. Kingsbury, research chemist at the Forest Products Laboratory, Madison, Wis., died on Nov. 27, 1958, at Madison from a heart ailment.

Mr. Kingsbury was born on Nov. 5, 1902, in Polk County, Wis. He graduated in chemistry from Lawrence College in Appleton, Wis., in 1927. Following graduation he became the assistant to the technical director of the Thilmany Pulp & Paper Co., Kaukauna, Wis. In 1929 he joined the USDA Bureau of Agricultural Chemistry and Engineering in Washington, D.C., as an assistant chemist and in 1943 became a chemist for the USDA Forest Service at Madison. He was responsible for much of the work in pulp bleaching and purification and in the development of a new and improved bleaching process, especially those of groundwood, semi-chemical and other high yield pulps from hardwoods. He was the author of many publications in the field of bleaching pulps for papermaking and chemical derivatives.

TAPPI DIVISIONS AND COMMITTEES

Reports of Activities

Adhesives Testing Committee

William Neuss, Stein-Hall & Co., New York, N. Y., Chairman of the TAPPI Adhesives Testing Committee, has announced that the membership of this committee is now as follows:

William Neuss, *Chairman*, Long Island City, N. Y.
William W. Sederlund, *Vice-Chairman*, National Starch Products, Plainfield, N. J.
Joseph P. Carey, *Secretary*, Dennison Mfg. Co., Framingham, Mass.
H. H. Bashore, Linde Air Products, Buffalo, N. Y.
Edward Bearman, Morningstar-Paisley, Inc., New York, N. Y.
R. W. Blomquist, Forest Products Laboratory, Madison, Wis.
Morris Breslouf, Polyco. Monomer Dept., The Borden Co., Leominster, Mass.
Don Carvalho, Darling & Co., Chicago, Ill.
Carl Erikson, Arabol Manufacturing Co., Brooklyn, N. Y.
R. D. Faunce, Reynolds Metals Co., Richmond, Va.
Karl M. Fox, Scott Paper Co., Chester, Pa.
Howard L. Heise, The Gummed Products Co., Troy, Ohio
Sted Herman, Shawinigan Resins Corp., Springfield, Mass.
Robert W. Howard, Fasson Products, Painesville, Ohio
L. J. La Brie, Morningstar-Paisley, Inc., New York, N. Y.
L. B. Lane, Armour & Co., Adhesive Div., Chicago 9, Ill.
John J. Minelli, Eureka Specialty Printing Co., Scranton, Pa.
Iven G. Nichol, Morningstar-Paisley, Inc., New York, N. Y.
George Peterson, Swift & Co., Chicago, Ill.
Robert H. Sams, Philadelphia Quartz Co., Primos, Pa.
Roger Shoals, Stein, Hall & Co., New York, N. Y.
Oscar V. Simonson, Milligan & Higgins, New York, N. Y.
C. W. Wilkins, Owens-Illinois Glass Co., Mill Div., Toledo, Ohio
Ralph Wicker, The Glidden Co., Chicago, Ill.
Christen Yang, Crown Zellerbach Corp., Camas, Wash.

Corrugated Containers Production Committee

The Corrugated Containers Production Committee met in the Netherland-Hilton Hotel on November 4, 1958. The following members were present:

K. Provo, Gaylord Container Corp.
R. W. Catzen, The Baltimore Paper Box Co.
D. Adams, St. Regis Paper Co.
L. F. Ashwood, Downing Box Co.
R. H. Bowers, Connelly Containers, Inc.
R. W. Buttery, Bathurst Containers Corp.
D. C. Dowd, Specialty Equipment Corp.
B. Mendlin, Cornell Paper Products Co.
W. Williams, Stone Container Corp.
H. W. Wilson, Royal Container Co.

The first order of business was the announcement by Chairman Provo, that he will not be available as chairman after February, 1959. Mr. Mendlin also will not be available as vice-chairman due to his participation in the division organization. A nominating committee consisting of R. Bowers and D. Adams was appointed to nominate persons to fill these positions. The chairman recommended that the committee consider a tenure of more than one year for the new officers.

Project No. 695. A request has been made to TAPPI for $500.00 to defray part of the cost of the statistical analysis at the University of Manitoba. D. Blackburn (project chairman) recommended that 10 machines be studied at a

Corrugated Containers Production Committee

cost of $55 per machine. K. Provo read Mr. Blackburn's report on No. 695. All attending the meeting agreed to allow their plants to be used for the collection of the necessary data as outlined in the above mentioned report. A discussion followed amplifying the objective of this project. The objectives of Project No. 695 are: To establish a standard set of factors for expressing adhesive consumption in terms of thousands of square feet of double faced A-flute board.

Project No. 694, Supervision. The problem of how far to carry this project was discussed. It was decided that Mr. Buttery's committee should complete the current survey and send the digest to all contributing plants. The committee will then be in a position to discuss intelligently the future of the project at our New York meeting. Additions to the report are planned by Mr. Buttery who will send questionnaires to all participants.

A report was made on the problems involved in studying labor costs by R.W. Catzen. It was decided that the Baltimore group attempt to make standards on one operation (the corrugator) and report at next meeting.

A committee to study supervisory training was appointed. The committee consists of Messrs. Williams (chairman), Ashwood, and Mendlin.

The committee decided not to discuss die cutting and printing layouts. With no further business to discuss the meeting was adjourned.

R. W. Catzen, *Secretary*

Steam and Power Committee

With R. V. Knapp, chairman, presiding, the Steam and Power Committee's luncheon meeting was held in the Bamboo Room of the Hotel Multnomah Portland, Ore., on July 30, 1958, with 12 committee members and four guests present. Members were:

H. R. Emery, St. Regis Paper Co.
J. G. Hoad, John G. Hoad & Assoc., Inc.
R. V. Knapp, Mosinee Paper Mills Co.
L. Limon, Graver Water Conditioning Co.
J. E. Mailhos, Bowaters Carolina Corp.
C. R. Podas, Pfeifer & Shultz
V. M. Sutherling, Longview Fiber Co.

Steam and Power Committee

B. M. Turner, International Paper Co.
H. B. Wallace, Foster Wheeler Corp.
W. B. Wilson, General Electric Co.
T. F. Woodward, Scott Paper Co.
W. M. Wyburn, Federal Paper Board Co., Inc.

Guests included:

V. P. Owens, Combustion Engineering Co.
M. A. Plant, MacMillan & Bloedel, Harmac Paper
J. O. Starkweather, Ebasco Services, Inc.
G. F. Stoneman, Chemical Processes Co.

V. M. Sutherling, a new member of our committee, met with us for the first time. The complete roster of the committee members is appended to this report.

Subcommittee Reports

Data Sheets

H. R. Emery reported in the absence of P. Nelson. The main activity to report since our Pittsburgh meeting was distribution of Mr. Yeakel's draft of guide specifications, "Centrifugal Boiler Feed Pumps." Comments from the committee have been accumulated by Mr. Yeakel and forwarded to Mr. Nelson for review.

A list of existing (many are obsolete) TAPPI data sheets has been compiled by TAPPI Headquarters. Data sheets were grouped according to committee interests for review by the different committees. This information is being forwarded to Mr. Nelson for review to be sure that all data sheets are withdrawn except those which are still up to date and useful.

Steam and Power Consumption (Project No. 420)

J. G. Hoad reported accumulation of additional ideas for use in formulating a questionnaire and accumulating data. A questionnaire will be drafted and reviewed with different mill people before being printed in final form for general distribution.

Paper Mill Power Plants (Project No. 475)

Due to the large number of follow-ups required, E. H. Donley's subcommittee report was delayed, but is now ready for printing.

Training of Power Plant Engineers (Project No. 476)

T. F. Woodward reported considerable progress on this activity, but all recognize the problem of preparing specific recommendations that can be followed universally.

To conclude this project, the committee voted to schedule the subject as a panel discussion at our 1960 Engineering Conference. Mr. Woodward will prepare a comprehensive bibliography of pertinent literature available for those interested in the subject and arrange the panel discussion.

Progress in Nuclear Power (Project No. 726)

H. B. Wallace is correlating a brief memo based on data received from the three boiler manufacturers. These data will be disseminated to the committee membership.

The consensus of the committee was that the economic application of nuclear energy for paper mill power plants is still several years in the future. Even so, the committee feels that an annual status or progress report should be issued to keep the committee informed.

Scope

The committee discussed the content and wording of scope to be proposed for the Steam and Power Committee. This scope includes all the revisions agreed upon at our Portland meeting and is as follows:

The Steam and Power Committee's function in TAPPI's Engineering Division is to:

I. Do the research and study necessary for the preparation of papers, special reports, and data sheets covering pertinent information and recommendations relating to:
   - A. The specification, application, installation, operation, and maintenance of:
     1. Steam generating equipment including waste fuel and chemical recovery units.
     2. Steam distribution and condensate systems throughout the mill.
     3. All prime movers and their place in the over-all mill heat balance when used for generator, paper machine, or other mechanical drive applications.
     4. Electric power generators, except for electrical design features.
     5. Auxiliary equipment, such as pumps, fans, instrumentation, and the water supply and water treatment associated with and necessary for operation of the mill's steam and power system.
   - B. Over-all steam and electric power reqirements as a guide in planning facilities for different types of new mills or mill expansions.
   - C. The specification, storage, and utilization of all fuels, including nuclear energy, and the disposal of ash and spent fuel.

II. Coordinate with other TAPPI committees to be sure activities are coordinated to eliminate duplication of effort.

III. Keep informed on the activities of other technical associations and engineering societies to be sure that use is made of all available information related to the Steam and Power Committee's activities.

Engineering's "Question-and-Answer" Committee

M. J. Osborne is responsible for activities of a newly formed committee charged with providing material for a regular feature section or column in *Tappi*. The purpose of this section is to give our members and readers a direct opportunity to get specific comments or answers to *their* questions.

J. E. Mailhos was appointed as the Steam and Power Committee's representative responsible for providing material to Mr. Osborne for *Tappi*.

1958 Program

The 13th Engineering Conference was well attended. The caliber of the Steam and Power Sessions was evident by the active audience participation during the discussion period.

The morning session had an audience of about 100 to hear two papers by M. O. Funk, of Combustion Engineering, and E. A. Kazmierski, of Babcock & Wilcox, on different aspects of "Steam Generators Designed for Multiple Fuel Firing" and a paper by C. H. Barnard, of Bailey Meter on "Controls of Instrumentation for Boilers Designed for Multiple Fuel Firing."

The afternoon panel discussion session on "Bark and Wood Refuse Burning" had an audience of 60 to 75. Moderator of this panel was C. R. Podas, of Pfeifer & Shultz, and panel members were:

K. H. East, Weyerhauser Timber Co.
R. Ellwanger, The Chesapeake Corp.
W. C. Rindsland, Minnesota and Ontario Paper Co.
T. F. Woodward, Scott Paper Co.

From all comments, it was apparent that the Steam and Power Committee's program was one of interest to a large cross section of those attending the conference.

1959 Program

The 14th TAPPI Engineering Conference is to held Oct. 11–15, 1959, at the Penn-Sheraton Hotel in Pittsburgh, Pa.

The program selected in balloting by the Steam and Power Committee is:

Papers:

"Progress Report on Atomic Power," by J. W. Magee, Jr., and J. H. Wright, of Westinghouse Electric Corp.
"Allocation of Costs for Process Steam and Electric Power in Paper Mill Power Plants," by G. D. Farrar, of General Electric Co.

Panel Discussion:

"Economic Limitations of Pressures and Temperatures for Pulp and Paper Mills, Including Chemical Recovery Units." Panel Moderator will be J. G. Hoad, of John G. Hoad and Associates.

Mr. Hoad is now completing plans and selecting panel members for this discussion.

1960 Program

The 15th TAPPI Engineering Conference is scheduled for Oct. 24–28, 1960, in Jacksonville, Fla.

At the Portland meeting, the Steam and Power Committee selected "Training of Power Plant Engineers" as the panel discussion portion of our 1960 program. T. F. Woodward will finalize details of this panel.

The committee will be canvassed soon for other suggested topics for the 1960 program. Suggested topics will be tabulated so the final program can be finalized by a series of votes by the committee membership.

Spring Meeting

Plans are to continue our very profitable spring committee meetings. March 30 or April 3 have been suggested and the committee will be canvassed to establish the exact date and place.

TAPPI Steam and Power Committee
Membership List—1959

H. R. Arnold, Continental Can Co., Robert Gair Paper Products Group, Greenville, S. C.
F. H. Coldwell, Nekoosa Edwards Paper Co., Port Edwards, Wis.
E. H. Donley, Babcock & Wilcox Co., New York, N. Y.
M. Ellis, Continental Can Co., Inc., Robert Gair Paper Products Group, New York, N. Y.
H. R. Emery, St. Regis Paper Co., Jacksonville, Fla., *Vice-Chairman*
G. B. Gregg, Cincinnati Gas & Electric Co., Cincinnati, Ohio
W. H. Hall, The Mead Corp., Chillicothe, Ohio
J. E. Hoeft, Owens-Illinois Glass Co., Mill Division, Tomahawk, Wis.
J. G. Hoad, John G. Hoad & Assoc., Inc., Ypsilanti, Mich.
R. V. Knapp, Mosinee Paper Mills Co., Mosinee, Wis., *Chairman*
L. Limon, Graver Water Conditioning Co., New York, N. Y.
J. E. Mailhos, Bowaters Carolina Corp., Catawba, S. C.
N. H. Mailhos, Brunswick Pulp & Paper Co., Brunswick, Ga.
J. W. Magee, Jr., Westinghouse Electric Corp., Philadelphia, Pa.
P. L. Nelson, Charles T. Main, Inc., Boston, Mass.
C. R. Podas, Pfeifer & Shultz, Minneapolis, Minn.
J. O. Starkweather, Ebasco Services, Inc., New York, N. Y.
V. M. Sutherling, Longview Fibre Co., Longview, Wash.
B. M. Turner, International Paper Co., New York, N. Y.
H. B. Wallace, Jr., Foster Wheeler Corp., New York, N. Y.
C. Wills, Halifax Paper Co., Inc., Roanoke Rapids, N. C.
W. B. Wilson, General Electric Co., Schenectady, N. Y., *Secretary*
T. Woodward, Scott Paper Co., Detroit Division, Detroit, Mich.
W. M. Wyburn, Federal Paper Board Co., Inc., Bogota, N. J.
G. L. Yeakel, Gilbert Associates, Inc., Reading, Pa.
W. H. Zieseniss, Combustion Engineering, Inc., New York, N. Y.

W. B. Wilson, *Secretary*

Engineering Data Committee

H. G. Ingraham, Chas. T. Main, Inc., Boston, Mass., has announced that the Engineering Data Committee will hold a meeting at 3:00 p.m., Sunday, Feb. 22, 1959, in Parlor F, Commodore Hotel, New York. All committee members are urged to be present.

Among the items on the agenda, Mr. Ingraham has included reports from each Engineering Committee representative as to his committee's procedures to be followed for the review of: (1) existing TAPPI Data Sheets under the jurisdiction of Engineering Committees, (2) those data sheets in process, and (3) proposed data sheets.

Mr. Ingraham also has announced the members of the Engineering Data Committee. These are shown together with the name of the Engineering Division Committee each represents.

Mr. Ingraham was appointed chairman of the Engineering Data Committee at the 13th Engineering Conference, replacing F. D. Helversen, Crown Zellerbach Corp., San Francisco, Calif., who has been a most enthusiastic chairman for the past two years. The picture shown was taken at the past Engineering Conference and left to right are H. G. Ingraham, F. D. Helversen, and H. O. Teeple. Mr. Teeple, TAPPI staff, New York, has replaced A. J. Winchester, TAPPI staff, New York, as secretary of the Engineering Data Committee.

Mr. Ingraham brings to his new TAPPI job a wealth of personal experience in the engineering aspects of the pulp and paper industry. He is a graduate of Armour Institute and has worked for Marathon Corp., J. Simonds, Bird Machine Co., and for the past eight years, for Chas. T. Main, Inc. His knowledge, accumulated over about 40 years of service in the industry, will prove to be of much value to the Engineering Data Committee.

Converting and Consuming Division

Meetings of the officers of the Converting and Consuming Division were held at the Sheridan-Kimball Hotel, Springfield, Mass., on Sunday evening, Oct. 19, 1958, and Tuesday morning, Oct. 21, 1958. The following individuals attended:

J. W. Field	W. A. Schenck
P. M. Goodloe	C. J. Seiler
W. L. Hardy	W. N. Stickel
W. E. Morris	R. C. Sturken
R. W. Reiter	A. J. Winchester

The appointment of W. L. Hardy as chairman of the 1959 Plastics-Paper Conference, to be held at the Edgewater Beach Hotel, Chicago, Ill., was announced. Mr. Hardy advised that he would seek to obtain the services of Robert Mosher as technical program chairman. R. C. Sturken will look into the possibilities for mill visits.

It was decided that the 1960 conference would be held in Syracuse, N. Y. It was further agreed that it should be held on a Tuesday, Wednesday, and Thursday, during the latter part of October. The meetings are to be held at a hotel rather than at the College of Forestry, but a visit to the College of Forestry Laboratory, will be arranged. A. J. Winchester agreed to investigate the best available dates which would not conflict with other groups such as The Packaging Institute and ASTM, and would make the necessary reservations for rooms.

It was suggested that the Wet Strength and Interfiber Bonding Committee be invited to participate in this 1960 conference.

As a site for the 1961 conference, it was proposed that we consider a resort hotel in the Ohio, Indiana, West Virginia, Kentucky area. R. C. Sturken and A. J. Winchester will investigate available sites and report at the February meeting.

It was also recommended that we avoid having future conferences at any hotel or in any location where racial discrimination existed.

A location in Canada was also suggested for consideration for future meetings.

The question of formalizing committee membership requirements was discussed, and it was generally agreed that the committees should approve new procedures in this regard. The application blank used by the Coating Committee was considered by the group to be a good method, and it was decided that each committee would ask their present membership to signify their continuing interest on a similar form and to use the blanks for all new applicants for membership.

It was also agreed that regular attendance at committee meetings should be required by all committee members. After an absence of two consecutive meetings a member should be notified and requested whether to confirm his continuing interest. After an absence of three consecutive meetings, members would be automatically dropped.

The question of improvement of the quality of papers at technical conferences, was discussed. It was generally agreed that this is highly desirable and that steps should be taken in this direction. In order to do so it will be necessary that active preparations for the technical program begin at least one year in advance of the conference. It is generally necessary to have a surplus of papers in order to be selective. In addition strict requirements should be set up for all of the authors and they should be properly notified to submit their papers well in advance. This will permit review by the committee to determine whether they are acceptable according to TAPPI standards.

The question of the expansion of the activities of the Converting and Consuming Division was discussed. It was pointed out that a large proportion of the total manufacturing expense in paper and related industries is concerned with the conversion of paper after it leaves the paper machine. Large areas of the paper converting operations are not represented by any TAPPI Committee or technical activities.

Walter Hardy suggested that a committee might be set up to handle waxed paper manufacturing. Other fields of activity which were suggested included latex saturation of paper, paper shipping sack, abrasive paper manufacturing, paper cup and container manufacturing, asphalt laminated paper, and gummed paper. R. C. Sturken was to investigate this question further and report at the February meeting.

R. C. Sturken, *General Chairman*

Precision Committee

A meeting of the Precision Committee was held at Savannah, Ga., Oct. 2, 1958, with the following attendance:

C. A. Bicking, *chairman*, The Carborundum Co., Niagara Falls, N. Y.
Carl F. Ackerman, Union Mills Paper Corp., New Hope, Pa.
C. E. Brandon, Miami University, Oxford, Ohio
J. H. Cowan, E. B. Eddy Co., Hull, Que., Canada
T. W. Lashof, National Bureau of Standards, Washington, D. C.
G. L. Maton, J. I. Thompson Co., Washington, D. C.
David W. Reid, Union-Bag Camp Paper Co., Savannah, Ga.
C. P. Spring, Owens-Illinois Mill Division, Toledo, Ohio
S. Steinberg, Army Chemical Center, Md.

Agenda Item 1. *Status of Literature Survey.* Mr. Maton had expected to have this in shape for publication by the end of 1958. However, due to moving of his office and the fact that he has to fit the work on his own time into a heavy work schedule, it may be delayed somewhat.

Agenda Item 2. *Conclusions from Data Submitted by Collaborating Mills.* Since this was covered in detail in the paper presented in a technical session by Mr. Bicking, it was not discussed in the committee meeting.

Agenda Item 3. *Final Precision Results from Beater Round-Robin.* Mr. Brandon will present a paper giving final conclusions from the first round-robin. A repeat run of the round-robin is now being planned to study the effect of aging. Mr. Brandon will be responsible for setting it up and analyzing the results.

Agenda Item 4. *Report on Tensile Round-Robin.* All sets but one of results on the round robin on the shipping sack tensile test are in, the method of analysis has been set up by Mr. Maton and checked by Mr. Lashof. Mr. Bicking has the tabulation of data received to date and will comment on it. It was expected that the last set of data would be in so that analysis could be completed this year.

Agenda Item 5. *Basis Weight Round-Robin.* Mr. Cowan reported that analysis of data from the first run had shown conflicting results from the participating laboratories. The within laboratory precision was fairly good and reasonably consistent. However, the laboratories agreed poorly. Mr. Cowan suggested a re-run using metallic foil. He will set this up and send out samples to the same laboratories. Mr. Bicking has made a series of experimental measurements of the original paper samples in the Quality Control Laboratory at Carborundum which confirms that the unsatisfactory results obtained may be pinned on the sensitivity of basis weight to fluctuations in temperature and humidity both within a laboratory and from one laboratory to another.

Agenda Item 6. *Discussion of other Cooperative Testing in Progress.* Mr. Lashof mentioned briefly a program on smoothness which is covered by a separate research project. The Precision Committee will have the benefit of results obtained. The National Bureau of Standards, APPA and TAPPI will collaborate in a study of tear in 25 laboratories. Mr. Lashof will follow for us.

Agenda Item 7. *Discussion of Future Tasks.* It was decided not to have a session on precision at the February, 1959, Convention. Instead, members are urged to offer papers on programs of other committees or divisions. There will, however, be a Precision Session at the 10th Testing Conference in Portland, Ore., in August, 1959.

In view of interest expressed at the meeting, approval of the national officers will be requested for additional members for the committee.

During the Testing Conference, Mr. Bicking discussed with Messrs. Wink and Zabel their work on developing an instrument for measuring specular gloss. A copy of their published paper and of the original report of the work have been provided as a basis for comment.

Also, a conference was held with John Tasman regarding the collaborative testing of the TAPPI Reference Pulp for its chemical properties. Although a minimum of precision information will be obtained from duplicate analyses in many laboratories, the primary object is estimation of the properties of the pulp. Mr. Bicking will follow up with suggestions for the round-robin and the analysis of the data.

G. L. Maton, *Secretary*

44th Annual Meeting

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Precision Data Available on Commonly Used TAPPI Standard Methods of Test*

CHARLES A. BICKERING

PRECISION data, unless derived from a carefully planned experiment, preferably preceded by a "pretest" designed to eliminate the causes of erratic results, should be quoted with caution. In the course of its research project, the Precision Committee of TAPPI has collected a great deal of data on repetitive testing of the same material from the files of the collaborators. Much of this is not directly usable because the variable factors have not been fully identified, or because the original objectives were limited, or because the results appear to be untrustworthy (i.e., are not in statistical control).

However, there are parts of these data, some of them submitted as the result of specific requests by the Precision Committee, which withstand critical scrutiny and which provide at least preliminary estimates of the precision of the methods. Fortunately, the most usable data are related to tests which the questionnaire sent to collaborators indicated were of primary interest to the industry.

Based on data of this sort, which can be used for preliminary estimates, the committee has planned and carried out certain round robin tests and is in a position to extend carefully planned round robins to most of the TAPPI Standard Tests.

This paper summarizes the precision results which have been calculated from selected parts of submitted data for use as order of magnitude estimates of precision and as aids in the planning of future round robin tests.

THE CONCEPT OF PRECISION

It is desirable to make clear some concepts generally held regrading the term "precision," in order to provide standard terminology in the application of precision data.

General Concepts

The measurement procedure by which a property of a material is determined may be looked upon as a process. In order that the characteristics of a measurement process may be defined, it must be possible to make repeated applications of the process under fixed circumstances. In other words, the process must be "in control" in the statistical sense.†

For a controlled process, it is possible to define such terms as "precision," by which is meant the closeness together of repeated individual measurements of the same material.

Precision of measurement must be determined by an operationally verifiable procedure, which means that the measurement process must be completely defined and the precision calculated from results of applying the process must be applied only to the process as defined.

Thus, although in concept precision is a generic term, in application it must be limited to a specific meaning. Interest may be in repeated measurements made on a single specimen (or several specimens from a homogeneous lot if the measurement is destructive), by a single operator or by several operators, using a single test apparatus or several, in a single laboratory or in several laboratories, on a single day or spread over several days, and so on. All of these things may be elements of the defined process and all may affect the pattern of distribution of the measurements. It is noted that the overall spread of variability will normally be greater the larger the number of different sources of variation included.

When precision is mentioned, a suitable descriptive title should be applied to indicate what cause system it is intended to include.‡

Quantitative Measures of Precision

The precision of a stated measurement process may be expressed quantitatively in terms of the standard deviation of individual measurements as estimated using a series of controlled determinations made by the process.

If the aim is to compare the precision of a measurement process with that of an alternative method, the ratio of the squares of the standard deviations (the variances) is used in the appropriate test of significance.

It is often considered desirable to state the numerical magnitude of the precision of a particular method as, for example, to say that method X has a precision of 0.002 in. (or 0.3%). The magnitude of the precision stated in this way depends upon whether one standard deviation of the individual measurements has been given or whether another multiplier of the standard deviation has been used.§

From these considerations, it would appear desirable when determining or stating a quantitative measure of precision of a method to do two things:

1. Define just what cause system or measurement process (operators, apparatus, laboratories, days, etc.) is represented by the set of measurements under consideration.

2. State whether the precision figure represents one standard deviation or some other multiple of the standard deviation (which makes it possible to choose any value of the expected percentage of the measurements it is desired to delimit).||

SUMMARY OF PRECISION RESULTS

Components of Test Variance

One of the useful ways in which precision results may be expressed is as the components of the variance ascribed to each of the steps in the measurement process. Of the 26 TAPPI Standards considered to be most important, data for 12 of the methods are complete enough at this time to be tabulated in this way in Table I.

CHARLES A. BICKING, The Carborundum Co., Niagara Falls, N. Y.

* This study has been sponsored by the TAPPI Precision Committee and financed by TAPPI Research Grant No. 135.

† See Part 3, ASTM Manual on Quality Control of Materials, American Society for Testing Materials, 1916 Race St., Philadelphia, Pa.

‡ Useful titles include: "within-laboratory precision," which includes sampling variability (specimens from a controlled process), operator variability, test apparatus variability, and variability due to the passage of time; and "between-laboratory precision," which includes all of the above, plus laboratory-to-laboratory variability. Such specific designation of the measurement process circumvents the necessity for using such ambiguous terms as "repeatability" and "reproducibility."

§ Any multiplier might be used such as the multiple corresponding to 90 or 99% limits, or the practical extreme of three standard deviations.

|| The useful information in a controlled set of data is presented by the mean, standard deviation and number of measurements. At least this amount of background information should be given to permit verification of the precision statement.

Table I. Components of Variance for Selected TAPPI Standard Methods of Test

Order of importance	Test no.	Name of test	σ within laboratory		σ^2 between laboratories
			At one time	Between times	
1	T403	Bursting strength	0.754	0.273	...
2	T410	Basis weight	0.40	0	...
4	T227	Freeness of pulp	...	5.8	81.0
5	T414	Internal tearing resistance	...	6.01	28.79
6	T404	Tensile strength			
		MD	1.62	0.64	...
		CD	0.38	0.12	...
7	T411	Thickness	61.10^{-10}	24.10^{-10}	...
11	T217	Brightness of pulp	0.35	0.02[a]	...
12	T452	Brightness of paper	0.127	0.042	...
16	T425	Opacity	...	0.78	0.09
18	T423	Folding endurance			
		$\bar{X}$ = 13	...	20	7.7
		$\bar{X}$ = 58	...	229	29
		$\bar{X}$ = 170	...	2705	2124
25	T451	Stiffness	6.518	3.042	...
26	T457	Stretch			
		MD	0.071	0.140	...
		CD	0.168	0.201	...

[a] Between operators.

Insofar as they are complete, the data in this table may be used as background information for the selection of sample sizes, in the design of new round robin tests, for calculation of the extreme limits of variation of results reported in conformance with a TAPPI Standard, or for calculation of the expected agreement of duplicate results.

Precision and Agreement of Duplicates

The precision, in terms of the extreme limits for all practical purposes,* of results obtained in conformance with the TAPPI Standards, within-laboratory and between-laboratories, has been calculated for the tests listed in Table I. Also, there have been computed the values within which duplicate results should agree and the number of specimens that would have to be tested with the variance experienced to obtain the agreement which the standards say are to be expected. These are shown in Table II.

The precision is obtained by combining the variance components of Table I in proper relationship to the minimum number of tests or specimens recommended in the Standard Methods.** All within-laboratory variances are combined to calculate within-laboratory precision. The between-laboratory variances are added to the within-laboratory variances to calculate between-laboratory precision. The square roots of the respective total variances are multiplied by three to give the plus and minus precision limits of individual results of applying the procedure.

* "Extreme limits for all practical purposes" are plus and minus three times the standard deviation. All of the results presented in this paper are based on a very large number of observations (200 to 1800).

** *Example:* The total within-laboratory variance for Test T403. Bursting Strength, is the variance within a laboratory between times plus the variance at one time divided by 10, the minimum number of tests recommended.

Table II. Precision of Method and Checking Limits for Duplicates for Selected TAPPI Standard Methods of Test

Test no.	Name of test	Extreme limits of precision: Within laboratory	Extreme limits of precision: Between laboratories	Checking limit for duplicates	Tests required: Limit	Tests required: No.
T403	Bursting strength	±1.8 p.s.i. (N = 10)	...	8.5% of 13.71	5%	29
T410	Basis weight	±1.9 lb. (N = 1)	...	4.5% of 59.65	2%	8
T227	Freeness of pulp	±5.1 (N = 2)	± 27.5	3.7%[a] of 138 (77–240)	2%[a]	7
T414	Internal tearing resistance	±3.3 g. (N = 5)	± 16.4 g.	8.8% of 53.2 (17–92)	7%	8
T404	Tensile strength	MD ± 2.7 kg.	...	11.5% of 15.0 (13–18)	5%	52
		CD ± 0.9 kg. (N = 10)	...	9.6% of 8.5 (7–9)	5%	38
T411	Thickness	±0.000165 in. (N = 10)	...	0.0001 (av. = 0.00314)	0.0002	OK
T217	Brightness of pulp	±0.85 (N = 6)	...	1.0 (1.25%) of 83	..	...
T452	Brightness of paper	±0.80 (N = 6)	...	0.73 (1.0%) of 74	..	...
T425	Opacity	±1.2 (N = 5)	± 1.5	1.7 (av. = 92.5)	0.5	56
T423	Folding endurance	$\bar{X}$ = 13 ± 4.24	± 9.4	46%	..	...
		$\bar{X}$ = 58 ± 14.3	± 21.7	35%	..	...
		$\bar{X}$ = 170 ± 49.2 (N = 10)	±147	41%	..	...
T451	Stiffness	MD ± 5.8	...	6.0% of 57.6	5%	15
		CD ± 5.8 (N = 10)	...	9.2% of 37.3	5%	34
T457	Stretch	MD ± 1.15	...	0.35 (av. = 1.35)	0.2	32
		CD ± 1.4 (N = 10)	...	0.55 (av. = 2.34)	0.2	220
T413	Ash of paper	±1.0 (N = 2)	...	0.475 (av. = 27.0)	0.2	12

[a] Plus and minus per cent from the average.

The value within which duplicate results should agree, the "least significant difference" between duplicates, is obtained by multiplying by the square root of two, three times the square root of the variance within one laboratory at one time (Table I) divided by the number of tests recommended.

The nunber of tests required to obtain the agreement called for in the Standards is found by a reverse procedure of computation.††

It will be noted that the information of Table I will provide clues as to what part of the test process must be improved if the expected agreement is to be obtained with the number of specimens suggested in the Standards.

CONCLUSION

The values of Tables I and II are to be considered as order of magnitude estimates of precision of the 12 TAPPI Standard methods covered. They may be improved upon by carefully planned and organized round robin tests, some of which are now under way. As they stand, the data should be helpful in designing future round robins most economically. They may be useful because they raise the possibility that when carefully defined, precision and checking limits for duplicates may be somewhat larger than usually supposed. The methods used in this paper for expressing the most useful concepts in connection with precision data may be helpful in obtaining concerted action on the great amount of work that still needs to be done to complete the picture of precision of TAPPI Standard methods of test.

†† $N = [(\sqrt{2} \times 3\sigma)/d]^2$, where σ^2 is the variance within a laboratory at one time and d is the limit of agreement in fixed measurement units or in per cent of the average value.

Presented at the Ninth Testing Conference of the Technical Association of the Pulp and Paper Industry, Savannah, Ga., Sept. 30–Oct. 2, 1958.

Graphic Arts I

Wednesday Morning, Feb. 19, 1958

The Graphic Arts Session I of the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, held at the Hotel Commodore, New York, N. Y., was opened with remarks by C. A. Morton chairman of the Graphic Arts Committee following which Miss Jacqueline Fetsko, chairman of the Program Committee, introduced the speakers.

The morning session was devoted to basic factors in ink-paper-press relationships. The first paper was "Hypothesis on the Mechanism of Ink Splitting During Printing," by James H. Taylor and A. C. Zettlemoyer, of the National Printing Ink Research Institute, Lehigh University, Bethlehem, Pa. Mr. Taylor who is working for his Ph.D. in chemical engineering at Lehigh, presented a theory in which the hydrodynamic situations that exist in roll milling were applied to the printing press. Involved were regions of reduced viscosity in the nip caused by zones of various pressures and shear rates as the paper hits the inked plate.

F. C. Oppen [Marathon Division, American Can Co., Rothschild, Wis.]: Your system of plate and cylinder is undoubtedly predicated on a rigid system. Peale, of the Swedish Graphic Arts Institute, made some dynamic pressure experiments in which he passed packing over a small form. When he put ink in the nip he got lower pressures than when he made the run dry without ink, and I believe he thought this was due to the lubricating effect of the ink. In other words, there was a certain give; there was a dynamic component in this system which wasn't discussed here. I know you can't talk about everything, but I just wanted to suggest that there may be some connection here which will be a component of further study.

Mr. Taylor: Yes. In this analysis it was assumed that everything was rigid and noncompressible. Now, not perhaps the next step, but several steps removed we will begin to consider what happens when you have a compressible surface and what happens when the plate and paper actually give under the conditions of printing. To do that, in addition to ink data, you would have to know the dynamic properties of the stock to much higher degrees than is known today. At the present time I can't even conceive of attempting that type of calculation.

However, it certainly must be borne in mind that all the properties, all the materials which are involved in this operation—the stock, its compressibility, its porosity, its roughness—greatly modify this extremely simple idea that we have here, and lead to vast changes under the practical conditions of printing. Again, realize that we have only been talking about printing with solid plates with a solid roller. When you have a character or a small letter being printed, you not only have flow along the nip, but you have flow outward in all directions, and this greatly modifies the situation. The mathematics of that are almost impossible at the present time.

Miss Cobb [Lowe Paper Co.]: This presentation has given us such marvelous new theoretical insights that I wonder if it's all right to ask a practical question. I have been very much interested since the first reports of the work on cavitation at Lehigh have filtered out and I wonder if you could give us a physical picture of the results of cavitation on the print. I also want to carry it over onto coating paper. In other words, are these little puckers or hollows that we see both in printing ink and in coating paper due to the cavitation?

Mr. Taylor: The cavitation studies have shown that the ultimate split of the film between two separating surfaces first originates with cavities or small bubbles formed within the fluid, when the tension exceeds the cohesive strength of the ink. The question is: does this cavitation phenomenon have a practical affect on the appearance of the print, or on the appearance of the material which is coated? (In coating you have almost the analogous situation; you have rollers and a fluid being split between two surfaces.)

I can only give you some of my opinions, based on the results we have seen. When the fluid splits, these cavities grow, and in growing together their edges, or the fluid between the cavities, form filaments which elongate and rupture, if the fluid has high tensile strength. If only a relatively small number of cavities form, these must grow large enough to split all the expanding volume in two, and the holes, or the dips, or the high spots will be much magnified.

However, if the cavitation threshold can be lowered, so more bubbles will be formed, then the fluid can split under lower conditions. Then instead of peaks and valleys you would have many more mountains and valleys. It would be my theory that these cavities, in growing and forming the ultimate form of rupture, do finally lead to the surface, and if the cavities can be minimized in their dimensions by increasing their number, perhaps that would lead to smoother coated films.

Albert C. Zettlemoyer [National Printing Ink Research Institute, Lehigh University]: I'd like to make a comment about the cavitation bubbles and their growth. The attention here has been focused on the viscosity. Taylor's analysis here has asked: what is happening to the viscosity, both with regard to rate of shear variation in the nip and the temperature variation in the nip?

When you ask the question: what forces do the bubbles have to act against in growing, then you find that there are other forces besides viscosity that have to be considered. One that has been referred to in a somewhat different connection is the initial force that the bubble has to operate against. The bubble starts to form somewhere in the region where the pressure falls below the atmosphere. As the bubble grows, it has to get bigger by creating more interface with whatever is inside the bubble, which is probably largely vacuum with a

few molecules from the liquid that might evaporate into this bubble.

However, one other force is surface tension, but the question has not really been analyzed as to how important surface tension is in the growth of the bubble. An elementary analysis which Myers and Miller made in our laboratories seems to indicate that the magnitude of the force that resists the bubble growth, insofar as surface tension is concerned, is many times more than the viscosity. Although this elementary analysis seems to indicate that surface tension might be the dominant factor, the temperature profile in the nip, which you have heard about today, must also be considered because surface tension decreases with temperature.

We believe we can test whether the viscosity or the surface tension dominate, because, as you perhaps will remember, the viscosity falls off semilogarithmically with the inverse temperature, whereas the surface tension falls off directly with the difference in the absolute temperature minus the critical temperature of the fluid. This is the equation of Raleigh and Ramsey. If we can study bubble growth by our equipment which enables us to follow the bubble growth with fast motion pictures or fast still pictures—if we can follow this with changes in the temperature, we might be able to decide how important surface tension is versus the viscosity.

Keith Bradway [Union Bag-Camp Paper Corp.]: You postulate that these bubbles are mostly vacuum and some molecules from the liquid, but I wonder if there isn't also occurring an entrapment of air at the incoming side of the nip, particularly on rough paper, so that this air that is entrapped could then be the source of the bubbles which are formed later. Since they are present probably to a greater extent on the paper surface, the film would split closer to the paper surface than in the case of two similar surfaces with ink splitting between them.

Mr. Taylor: That is an alternate hypothesis that has been offered, and certainly as a hypothesis it has some merit. My own feeling is that if air is trapped between the surface of the paper and the ink film, the bubbles would have to grow out from the paper surface. Then you would find the splitting right at the surface. You would see unprinted portions, or unprinted points, although there can be air diffusing from those bubbles into the film, and leading to the split, perhaps, within the film. But the fact that the transfer variation is from a split at the center to very close to the paper as you change the ink properties leads me to think that the bubbles tend to form mostly at the ends, and the nonsymmetrical factors are moving out from the center, rather than moving in from the paper as you change these properties. Certainly this other hypothesis cannot be completely discounted. We cannot disprove it at present, or prove it.

Mr. Zettlemoyer: I think it's worth while commenting about the bubbles of air that are obviously in ink. We know that ink contains air. I think we have to go along with Taylor, as far as our own thinking is concerned, that we don't believe that air from the paper at the moment is critical; but this is another way of thinking about it, and it deserves further thought.

It is probably true, however, that air bubbles in the ink give rise to the bubbles that are finally produced. If you look into cavitation theory, it is found that dissolved molecules would be unlikely to be centers for the start of bubbles. In other words, you have to have more than one molecule of the thing there—of the air, let's say—in order to start a bubble, cavitation theory says. Most of this cavitation theory has been done in superheating of liquids, but it's a very similar phenomenon, of course, so it's very likely that bubbles get compressed in the high pressure region of the nip to very, very small dimension, and grow again, and finally allow the thing to be seen photographically. The pictures we take are taken at the order of 2 millionths of a second, and it's rather interesting that the first bubbles we see are already large. We don't see them start very small and get large gradually. In other words, the rate of initial growth is very, very great.

Another thing we know is that if you pigment a fluid, the number of bubbles is greatly increased. This might be due to occluded air at the surface of the pigment particles, which then catalyzes the cavitation. It also might be added that any air that's in the bubble will help the bubble to grow. It suggests that you can make bubbles grow by adding something which will increase the number of molecules inside of the bubble.

Joe Frank [Champion International Co.]: I'd like to ask the question: what connection does the partial pressure or volatility of the solvent have to do with this? You expect bubble formation when you reach a negative pressure but your rate of drop is so great that I would expect some volatilization to go on even before you reached considerable negative pressure.

Mr. Taylor: The question as to what is present within the bubble is subject to considerable conjecture. Studies on cavitation have shown that very pure liquids can sustain appreciable negative pressure and can withstand considerable tension. However, real liquids which have sites of nuclei can seldom withstand pressures below one atmosphere, and they can form bubbles any time that pressure is below the vapor pressure of the fluid. For calculation purposes we have usually used 1 atm. of negative pressure, or 1 atm. of tension, but that is somewhat arbitrary. We feel that the actual pressure at the point where the bubble forms may be anywhere below the vapor pressure of the fluid, possibly 1 atm. of negative pressure—seldom below that, because studies have shown that they do cavitate not much lower than 1 atm. But the vapor pressure of the material certainly contributes. That is one of the causes of bubble formation and bubble growth.

However, real systems and very pure systems can withstand some tension greater than that exerted by the vapor pressure. It is like the case of superheating in boiling. You know that some water in a beaker may be heated to considerably above 212°F. before it will start to boil. There you have the liquid still maintaining its liquid state, although the vapor pressure is above atmospheric. You need some nuclei to get this boiling started; then bubbles form all in a rush, and you get foaming, or a great rush of bubbles. The same thing forms in cavitation. You have cohesive forces tending to hold the molecules together, although the vapor pressure says they should be separated. That is why you can have tensions in the fluid greater than the vapor pressure of the fluid.

The next contribution was "Print Testing on a Laboratory Rotogravure Press," by Walter Roehr, of the Kimberly-Clark Corp. Included was a discussion of variables affecting graininess in highlights, such as cell diameter, mean nip pressure, and smoothness, compressibility, and flexibility of the paper.

Charles Perlman [Equitable Paper Bag Co.]: I would like to know how to specify in practical terms to a paper mill what you want in terms of printing qualities. When you want to print by the gravure process, what would you specify?

Mr. Roehr: That's difficult to say, because we're still trying to find physical test measurements that will predict how the paper is going to print. One of the reasons why we go into the press method is because our physical tests just don't tell us all the story yet. We hope, of course, to get to the place where we can make physical tests that will tell us the whole story.

Mr. Perlman: Is there any combination of individual tests, like smoothness and compressibility that you can specify that would in composite give you the desired results?

Mr. Roehr: At the moment I don't think that has been worked out.

Mr. Robertson [Howard Smith Paper Mills]: What are the main factors affecting wear of the highlight areas?

Mr. Roehr: A number of things will wear the cylinder, such as excessive pressure on the doctor blade and gritty particles that get into the ink, either from the paper or from some other source. One of the things that is in favor of the bell vein-type etch or any type etch that varies both depth and size, is that you don't have to go to the extremely shallow cell, so that the wearing will be more gradual. In the standard type etch, where you get to extreme highlights, the etch is so shallow that the slightest amount of wear will cause it to disappear.

Mr. Zettlemoyer: If you had run the press slower, would the filling of the etch dots be different? We have found that filling a grindometer with heavier inks varies considerably with the speed of drawdown, therefore I think it's pertinent to ask whether, if you had run it slower, would you have increased the filling, or at least wiped out that center transparency, or lack of ink film thickness there.

A second question has to do with the rubber rollers. I am wondering whether a plastometer registers all you want to know about the behavior of the roller. Perhaps of more importance is the resiliency of the entire thickness from some kind of rebound measurement, rather than just the surface properties as measured by a plastometer or durometer.

Mr. Roehr: I think you are quite right. As far as the degree of filling of the cell goes with speed, we haven't gone into that.

Mr. Adenspiel: Have you looked into the direction in which the sheet is going through the press? In other words, is it being printed in the same direction it is made? Or if it were rewound, 180° that is, would it affect printing quality?

Mr. Roehr: In some cases we think we see some difference from a 90° turn, but since practically all roto is done from web, we automatically paste our samples on so that they are printed in the machine direction. Conceivably a 180° turn could make some difference, but I think it would be minor.

The next paper, by W. A. Wink of The Institute of Paper Chemistry, described "An Ink Applicator for Supplying Ink to the Distribution System of Proof Presses." This subject is very pertinent, for as Mr. Roehr mentioned, press tests are really the best tests for the printing properties of paper, but one of the problems involved is maintaining a constant ink flow throughout the period of testing.

Mr. Oppen: I am very interested in the certainty of the ink control of this system, and I think it unquestionably is almost better than we can use. But there's one item that bothers me, and that is Mr. Wink's reference to cleaning the entire plate between prints. It has been my experience, and I think not only mine, that when the plate is first inked, the first print is apt to be anomalous. I know that at least one system of testing recommends that you discard the first couple of prints, because they, in effect, condition the ink bringing it into an equilibrium condition. I know that ink transfer studies are apt to give a wider spread, if you use this cleaning technique each time than if you use the plate in an equilibrium condition.

I might say that we have gleaned those auxiliary depleter works from your apparatus. We assume a 50% ink transfer, and simply wipe off half of each plate, to remove approximately half the ink between prints. We of course weigh the printing plate to determine how much ink actually is on the plate. I think you will find, especially if you are trying to do smoothness studies with very light ink applications of the order of 1 or $1^1/_2$ g. per sq. m.—you will have a dickens of a time. That's my prejudiced opinion.

Mr. Wink: You can move your distribution system back and forth as often as you like. This thing, I think, has its major application where you are doing comparative work. It makes a difference how many times you take the carriage over the plate.

Mr. Oppen: I think it isn't just putting the carriage over the plate. I think it's the squash of getting the printing on the plate and driving the ink film into intimate contact with the plate. I think that's a factor.

Mr. Wink: As we are doing it here, experience so far indicates that we can get a very reproducible printing job.

Mr. Lyons [E. B. Eddy Co.]: Mr. Wink, in your second unit that you described, is that indexing wheel automatically turned or manually turned?

Mr. Wink: It could be by means of a ratchet. Actually, what we do there is this. Each time we return the carriage to the press one of the first steps we go through is to turn up that wheel the desired number of degrees. In other words, you have made the application. You proceed with your print. Of course, you automatically deposit the ink on the return. You start your distribution, turn up the index, and then proceed with the washing of the plate as soon as the other odd little bits of chores have been done.

Marvin C. Rogers: I wanted to comment a little bit on what Fred Oppen said. I think our experience has indicated that there is a substantial problem of quality relating to the cleaning of the plate and the re-inking, as you have mentioned, and passing the roller over is quite helpful and quite important.

I am a little puzzled about the accuracy that you may get with uniform application of ink to the inking system, and then a relatively nonuniform removal, which will come from a half tone which removes the ink uniformly on the areas that are in contact, but does not have a uniform number of contact areas. I wonder how many proofs you have pulled from it in order to establish this accuracy of $2^1/_2\%$ that you obtained, and whether or not these traces run on the printing of cellophane or an acetate sheet, whether the distribution across the sheet remains as uniform at $2^1/_2\%$, or whatever you have arrived at.

Mr. Wink: The whole scheme is designed to remove a fixed amount of ink from the system, and this is all independent of the printing characteristics of the paper which you are going to print subsequently. Since we raise the distribution system when the carriage is in its forward position, there is no further contact made. The form rolls contact only the clean plate and the auxiliary plates which are placed on the press.

Mr. Rogers: Is this a solid plate or a half-tone plate that you are talking about?

Mr. Wink: Much of our work has been done with solid areas, but it could be done with others, as long as you have a plate or auxiliary plates along the entire width of the plate.

Mr. Rogers: The thing that was disturbing me is that a highlight, for instance, on one side of the plate, as compared with a solid on the other, would not remove the same amount of ink, and your application of a uniform layer could be disturbing to the results.

Mr. Wink: In other words, it has to be symmetrical, or a solid color?

Mr. Rogers: For test purposes you should not get into trouble, but I wondered what the distribution was.

Mr. Wink: No, for the sort of thing you are talking about you would end up taking off more ink from one side than you would from the other.

Mr. Rogers: Yes.

Mr. Wink: You see, why we get these rapid distribution times is because we're just distributing ink around the roll, and we don't have to depend very much on the vibrator roll. We don't have to iron it out very far and carry it for a very great distance.

The last paper on the morning's agenda was from West Virginia Pulp & Paper Company. Bob Carmack, from the Williamsburg plant, discussed the problems that he came across with "Roller Composition in Proof Press Printing," and how this problem was solved.

Mr. Rogers: I think that the work that's reported here and the statements that are made can't be over-emphasized—that is, the importance of the roller to the proofing operation. It's particularly true in multicolor proofing, where we have

experienced exactly the same performance. If you understand the multicolor printing problem you can see that the actual printing characteristics of these inks can be altered, so that the proofs that we get from them can give you an infinite number of trapping combinations. It makes it virtually impossible to reproduce on the production equipment, and I have been trying to find somebody to serve as a missionary on that to prove that it is a problem to advertisers and engravers.

You indicated that you had ten runs, each exhibiting the same performance. I wondered whether the rollers were actually solvent cleaned prior to each of the runs, and then a 30-min. period for distribution following that. If so, have you made any attempt to find out what takes place in that nearly 30 min.? That is, have any proofs ever been made to watch this progression downward, and then back up again to watch this amount of ink film with which you are printing?

Another question: you have indicated that the soaking of the roller in the vehicle did not produce a change in performance, and yet you have used the soaking test—the roller manufacturer—as an indication that you had a poor material. I wondered how you reconciled those two stories.

One further comment, and that is that the thiofilm rubbers and the fluorinated rubbers are pretty good candidates for that kind of a roller.

Mr. Carmack: We cleaned the rollers before each test run using naptha as a solvent. But we did not do any testing in the initial 30-min. distribution period, which we considered to be the required time to distribute 2.3 g. of ink thoroughly.

As to other roller compositions, a fluorinated compound was tested, but the results did not appear as satisfactory as what the ST-155 was.

Mr. Rogers: They are very difficult to make, and the roller manufacturers object to using them.

Mr. Carmack: Yes. That was one objection, and another thing was expense.

Mr. Shepherd: [Howard Flint Ink Co.]: What did you consider normal transfer? You had a line in there on your curve which indicated that you had reached a normal transfer point. Is that the point where the rollers no longer appear to absorb, or something of that kind?

Mr. Carmack: That is correct. That level would be 39.9 plus or minus 1.9 mg. As long as we were able to get weights within that range, then we assumed there was no further absorption.

Mr. Shepherd: Why did you consider that normal?

Mr. Carmack: It was selected by experimentation. We wanted to print a reduced ink film thickness to show defects in the paper surface. We reached a point where we could control ink within a range, and that range happened to be 39.9 $\pm$ 1.9.

Graphic Arts Session II

Wednesday Afternoon, Feb. 19, 1958

Graphic Arts Session II of the 43rd Annual Meeting of TAPPI convened at 2:05 p.m. with James W. Wing, Gair Paper Products Group, Continental Can Co., Inc., presiding. The symposium was entitled "Laboratory Press Testing of Paper and Paperboard."

The first paper was the result of a Graphic Arts Committee project: "Survey of Proof Press Printability Test Procedure," by W. I. Stinger and F. C. Oppen, of Marathon Div. of American Can Co., and K. L. Strachan, of R. R. Donnelley & Sons. Fred Oppen made the presentation, summarizing the results of 51 replies to a questionnaire sent out to 125 companies. Presented were types of proof press tests, methods for print evaluation, and supplementary tests in current use.

Frank Bonsagni [Monsanto Chemical Co.]: When you use a constant ink level replenishing the ink level on the roll, what's the effect of the ink drying out, if you are doing a long series?

Mr. Oppen: Of course your proof press test has to be set up with that in mind. You may use a tack-rated ink; they are nondrying, having a mineral oil base. People run 3 to 4 hr. or all day without washing up.

If you are using gloss inks or inks with a high drier content, you have to work fast. Your period is limited to half a dozen prints, or at most 20 min. to half an hour of operating time; but you have to select your ink.

What it amounts to is that if you are print testing and you are not critical about ink, you would select a nondrying ink, but if your test requires the effect of a particular ink which is drying in character, then you have to operate accordingly.

The second paper of the afternoon was "Preliminary Experiments in the Use of the NPIRI Printing Gage in the Printability Testing of Newsprint" presented jointly by both C. F. Geffken, of J. M. Huber Corp., and Solomon Steinberg, of *The New York Times* with the assistance of Mr. Kurt Herrmann. The paper was concerned with the correlation between visual rating of production prints and grindometer plate prints.

Mr. Oppen: Please explain how the numerical values for the production prints were obtained?

Mr. Steinberg: The values were taken from visual ratings for each sample submitted to a judge. A judge was given three prints on each wire and felt side cut, and he rated them 1, 2, and 3, and then they were rated exactly as we did on the wedges.

The next paper "Techniques for Running Print Quality Tests on a Lithographic Press," by George W. Jorgensen, was presented by Charles H. Borchers, of the Lithographic Technical Foundation. There was no discussion.

The last paper of the afternoon covering boxboard, was "Smoothness Measurements with Ink Films" by A. T. Luey, of the Boxboard Research and Development Association. Mr. Luey discussed ink film requirements at various impressions to obtain complete coverage. He derived an empirical formula producing two constants for evaluating printing smoothness, which was concluded to be a function of free surface smoothness and the amount of impression applied.

Joseph Aid [Continental Can]: Does that include both coated and uncoated boards?

Mr. Luey: There was only one sample of coated board.

Mr. Aid: What I was getting at is whether this relationship of K_1 and K_2 held up on coated board.

Mr. Luey: It did.

Mr. Aid: It did? I would think that the different type of roughness would throw that out; in other words, where you have craters instead of little hills.

Mr. Luey: As a matter of fact, my correlation between calculated and experimental values on the coated sheet was not quite as good as the others. The values of K_1 ranged from 775 to 13,500. Sample no. 6, the coated board, had a value of 1500. There were several uncoated samples that had a lower value of K_1.

Roy Traben: Would you explain this step wedge, plate wedge of controlling ink film thickness?

Mr. Luey: The ink film thickness is controlled in this series of tests by adding a specific volume of ink to the press. From the area of the distribution system and the volume you can calculate the thickness of the ink on the rolls. I used the figure of about 50% removal from the plate. I knew this wasn't absolutely correct, but it was reasonably close, and that's why, after going through a series of a dozen proofs, I went back and re-inked the press and checked myself at a point along the line.

Actually, the size of the plate in relation to the total ink distribution system was relatively small. The amount of ink removed was in the neighborhood of 2% of the total, or

under that, and I just kept a calculation of the residual ink film thickness, based upon the per cent removal for the proof.

Mr. Rogers: I was interested in Luey's correlations of Scheid smoothness with K_1. K_1, as he presents it, is essentially the height of the rough spots on the piece of board, something like this. [Illustrating on blackboard.] By the Scheid method, the light comes across the top of this high spot and casts a shadow. Then the Scheid smoothness is apparently the angle—alpha, let's say—that gives some change in appearance, whatever that change is.

Now, if K_1, is a measure of the height of this rough spot, we can in effect set that up as the ordinate, or the altitude of that particular triangle, and this abscissa here is some constant value. It doesn't make any difference what it is. It can be a constant C. Therefore, you ought to be able to say that the tangent of K_1 divided by the tangent of alpha ought to be equal to the constant, if his correlation is any good.

So, taking the various K's he's got 2100, 3500, 4100, and so on; and taking the tangents of the Scheid angles for those particular readings, and dividing one by the other, we ended up here with constant values: 1140 here, then 4170, then 1700, 1000, one about 600, one 1140, one 1100, then 680, 1130, 740, and 960.

If you are a little liberal in your interpretation—I haven't gone into the mathematics of it—they do tend at least to revolve around a value somewhere in the vicinity of 1000. They are all pretty good except for the one that's 4170. I thought it was rather interesting, because he did show a correlation that was arrived at by plotting the curve, and here's one with an analogy of the angle against this smoothness, he calls it, which is a measure of the height of that rough spot, and it seemed to me it came out to show a reasonably good story.

Dick Trefla [Watervliet Paper Co.]: I think that picture could be strengthened, too, if you take into consideration the fact that in the Scheid smoothness tester your end point depends upon an optical illusion. While our experience is not enough to come up with all degrees of smoothness, we do know that as we get into coarser surfaces—and of course most of these surfaces would be comparatively rough, compared to the type of paper we usually work with—the degree of error in determining that degree of angle of optical illusion becomes greater, because you are playing with a pure optical illusion. The greater the depths that are involved, the more margin of error there is in that over-all optical illusion, so I would say, based on that premise, that this correlation is quite good.

Mr. Luey: One point, if I could move your readings 1° here and there, my correlation coefficient would have been essentially 100%, and the graduations on your instrument are every 5°.

Mr. Oppen: In degrees of parallelity of light source, speaking of the Scheid smoothness tester which we use, that adequate for our own smoothness calculations, but as far as being a real precision instrument, there are times when I'm sure that the intersection of the beam in the binocular microscope is not in exact accord. There are errors, but if you had 1° correlation, I wouldn't say it was bad.

Mr. Luey: My basic idea in using the Scheid was to substantiate the theory that the initial roughness of the board was one of the major parameters in determining the printing smoothness.

Mr. Zettlemoyer: I simply wanted to comment that the correlation that would be of interest to extend this work would be a correlation for studies on the same type of stock, but variations within that type. Isn't that what we are mostly interested in with regard to the measurement of printing smoothness? We would like to know what the correlation is for a given stock within different samples of that same type.

Mr. Luey: Of the 11 samples, 10 were white patent coated news. They varied in caliper, basis weight, amount of clay coating or pigment loading in the top liner, whiteness, and brightness. One was what you call a super-super white patent coated news. It was really a beautiful sheet, and had the K value of 775.

However, when I listened to various papers this morning on the things that could affect the results I thought I was lucky that I didn't know about them, because if I had known about them in the beginning, I probably would have been scared to go into this thing at all. [Laughter].

I did check press speed, and my check was running it as fast as I could, and also very slow. I didn't find any difference in my printing smoothness determinations doing that. I agree that speed will affect a lot of other printing tests that you might want to investigate, such as tack, and so forth, but it didn't affect the printing smoothness tests.

Also, I used an IPI tack-rated ink, no. 1, because I wanted to eliminate any possible confusion with pick.

Mr. Zettlemoyer: I'd like to comment once more then. I think a very, very interesting conclusion, if you compare a variety of different studies—for example, ours, with our K constant against the Scheid, or many other types of smoothness tests—we get a good correlation too; yet we are using a different ink than you are. This is a very happy situation, because it means that when one varies the ink, at least within some range, you are not going to get a different order in which the stocks are ranked.

Mr. Luey: Also, with regard to a comment made this morning about the effect of ink roller on ink film thickness, since I was using someone else's equipment, I didn't want to dirty the set of rollers that they use for color matching. So I used an old set which was smooth and essentially very shiny. Apparently I was lucky in selecting these, because according to the information presented this morning, this would be a condition that would be desirable if you didn't want inking rollers to affect the ink film thickness.

I did make one test on a different Vandercook press with an adjustable bed plate and a brand new set of rollers. I just couldn't get below around 0.009 impression no matter how much ink I put on. I had thought maybe there was something about this press—maybe the bed moves a little. But perhaps it was due to the new set of inking rollers.

Cylinder Board Session II

Tuesday Afternoon, Feb. 18, 1958

Cylinder Board Session II of the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, held at the Commodore Hotel, New York, N. Y., convened in the West Ball Room at 2:10 p.m., G. T. Renegar, Container Corp. of America, Philadelphia, Pa., presiding.

Chairman Renegar: The afternoon session of the Cylinder Board Committee will now come to order. Our first paper for this afternoon will be presented by Mr. Goodwillie, of Beloit Iron Works, Beloit, Wis., on the Stevens vacuum former. As you all doubtless know, there has been much work in the cylinder board field over the past years on various different types of vacuum formers, and this is one, I believe, that has proved commercially to be sound.

[Mr. William Goodwillie presented a prepared paper.]

Thank you, Mr. Goodwillie, for a highly informing paper, and I have no doubt in the discussion period which will follow that we will have a lot of discussion and quite a few questions on the Stevens vacuum former.

At this time we will proceed as usual with our discussion period, and I would like for the authors who presented their papers this morning and the people designated to discuss those respective papers to approach the platform.

On questions directed from the floor, I would request that every man announce his name and the company with whom he is affiliated, which will enable our stenographer to have a

more complete set of minutes of the discussion period, as the entire program will be printed in *Tappi*, so that everyone can read it and think about what has been said at his leisure.

The first paper presented this morning was by Mr. Kumler. It will be discussed by Jim Harrison, of Michigan Carton, on "The Utilization of Wastepaper."

MR. HARRISON: In reading over Mr. Kumler's paper, I feel he did a very good job of covering some of the aspects of wastepaper usage. His statistics, I think, are good. I cannot be as concerned, perhaps, as he would indicate, about the decline in its use, because if you figure in percentages, it is different than in tons. Actually, the decline in the use of wastepaper in tons was relatively small in spite of the fact that there was lower production last summer. Compared to pulp, wastepaper came up a little bit, if you analyze his figures in the paper.

In terms of supply, I don't think anybody can argue that there is not an adequate supply of wastepaper available. The question is the quality, so I would like to skip over to the problems it presents.

And this point that he made—this W-54 of the Wastepaper Institute, and what they consider as a challenge for the wastepaper operator—I remember reading those a couple of years ago. They have these small factors of 5% of this, or 2% of this, or 1% of that. Well, if you are going to use wastepaper, you might as well get down to 0%, because those are the facts of the case.

I don't know how to do it. If I did, we would have a lot less problems with wastepaper; but I think that is one of the problems, and I think that the Wastepaper Utilization Council should consider that as a goal, not to have these 5 or 10% of tolerances for material in wastepaper, because if your wastepaper is to compete successfully with pulp and with other materials which are produced by various mills, we are going to have to get rid of these miscellaneous percentages.

I think that probably that is the most important part of the paper from the standpoint of the people who use wastepaper. As far as the mill processing, there are certain things, you can do. Mills can keep adding equipment to take the rejects out, but the question is: how far can you afford to go in terms of dollars and cents?

I think one of the areas—I may be off base on talking about it but I'm going to do it anyhow—which I think wasn't stressed enough in the paper is the fact that there is a pure dollars and cents gain to the people who generate wastepaper if they would segregate it at the time it is manufactured, because the difference between clean wastepaper and dirty wastepaper is tremendous. It is true today when the market is low the same as it was when the market was very high, and it would certainly help a lot for the average user of wastepaper.

I think that if the converters who generate 5000 and 10,000 tons would realize the economics of the situation, they could well afford to spend a couple of dollars to get $10 out of it when they sold it. In looking at certain operations—I am not familiar with all of them, but certainly some of the operations with which I am familiar, the wastepaper that certain converters generate is the difference between a profit and loss to those companies. I know of operations where the percentage of wastepaper they sell amounts to 15 or 20% of what they actually buy. Now, if they would really work to upgrade their wastepaper, and keep these 1, 2, 3, 4, 5, 6% of materials that cause all the trouble to the user, both the inking mills and the wastepaper mills, I think there would be a real gain.

There is a real field for the Wastepaper Utilization Council that Mr. Kumler represents. He mentions here what they are trying to do, and I think it is an important field.

CHAIRMAN RENEGAR: Jim, do you have any questions you would like to ask Ralph?

MR. HARRISON: There is a point that he mentioned on a pressure sensitive tape to replace asphalt tape. To all of us who have any connection with kraft corrugated, or jute corrugated, or anything like that—that is very important, because I do not know anything that those who operate a mill think is any more important than an asphalt spec. It might be worth a little more comment to outline what can be done on that score.

MR. KUMLER: To take up the last point first, I did not emphasize the box tape very much, because it is working along, and I just did not know how far I should go into it today. It has been taken up with the tape manufacturers, and it seems as though we have a lack of communication between the box manufacturers and the tape manufacturers. That is what we are trying to establish.

For instance, I have had more than one tape manufacturer say, "Well, my stuff is all right. I don't hear anything about it. I don't get any complaints. It must be okay." But we know it isn't. If the box people will get together and tell the tape manufacturers what they want and what they must have, I think we will go a long way toward solving that problem. The situation is just really getting started, and so I do not believe it would help any to discuss it at length here. The tape manufacturers have a technical committee, and one of the things on their agenda is wastepaper utilization. Now, what more can you ask? They're receptive. Now, I think we are about to get a group from the box manufacturing end to come up and say what they want. You know, there is much that could be done in various fields of wastepaper, if people would just stand up and say what they want.

That brings me to another question which was referred to indirectly by Jim Harrison. One of the troubles that we have is a lack of unanimity on the part of the buyers of wastepaper. A dealer gets hold of something and ships into a plant, and they reject it. Well, that doesn't discourage him too much. He moves it to some other dealer and tries to sell it to him and he may be successful. If he can not he moves it to another fellow. I have been told that the same bale of wastepaper has appeared three times in the same mill, rejected each time, because one mill will accept what some other mill will reject. So the dealers are encouraged to keep trying, and finally somebody who isn't quite as alert as the others takes it. The dealer worries about it and finally he gets rid of it, but if it were understood that this lot is not acceptable, it would never come in the first place.

Now, there is one other thing. I am talking about the generators being segregated. Of course, that is probably the principal objective of the Wastepaper Utilization Council. To certain people, the money they get for it is a good incentive, if you just bring it home to them that they get more if it is cleaned. You have a good, solid argument, but we have a lot of fringe people. Some of the people who are supplying wastepaper to our industry are having to pay to have their wastepaper hauled away. They do not get any money for it. They may either have a very small amount or they may be isolated so the dealer can not afford to spend $50 to send a truck 50 miles to pick up one truck of wastepaper. You cannot expect them to do it. And yet some supplies come from that sort of source, so they are charged to have it hauled away.

We are doing the best we can to influence the suppliers as far down the line in that respect as we can, but it is a problem and a very serious one.

CHAIRMAN RENEGAR: Does anyone in the audience have any questions that they would like to ask Mr. Kumler in regard to wastepaper?

MR. TARRANO [James Tarrano Sons]: Presumably everybody in the room is interested in the utilization of wastepaper, but in view of the present market, has anyone got any particular practical ideas as to how you might improve the situation at this particular time?

MR. HARRISON: This is purely a matter of opinion but

I agree that your mixed and news, are at a reasonable price. However, I think top quality grades, if the wastepaper dealers would separate and guarantee them, could be improved. I know certain areas where clean corrugated cuttings are not available, and I know there is quite a difference between that and what you buy as corrugated. I'm sure somewhere in this area there is something to work on.

Mr. Kumler: Just recently I have been making a survey. It's not very complete, but I have been trying to find out and get some idea of how our program is working, and who is responding to it and who isn't. I did get the comment that, "It's a matter of price. If we got any money for our wastepaper, we could do something about it, but as long as we don't get any money from it, why should we spend any effort at all to segregate it?" It's all a question of degree, but the question of price does enter into the picture.

Mr. Werdouschegg [Case Bros.]: What steps have been taken to keep the rubber bands and such rubber articles like tape rubber out of the wastepaper?

Mr. Kumler: The principal thing that we are stressing in the Council is adhesive rubber. That seems to cause our people more trouble that anything else. Of course we're trying to cover the whole field, not only adhesive rubber, but vulcanized rubber too. We are going back through dealers to the generators, asking them to be careful about what they put in their waste. That works out all right with industrial establishments where there is some possibility of control, but a lot of stuff comes from wastebaskets in offices and office buildings, and I haven't figured out yet what we are going to do.

Mr. Werdouschegg: Primarily, I was concerned with bundling up tabulating cards with rubber bands in groups of 100 or 150, and naturally all those tab cards and rubber bands cannot be separated. You still don't get any more 50 or 60 per cent of wastepaper, and I don't think people can afford to buy tab cards with rubber bands in them.

Mr. Kumler: That goes back to the offices from where they come. I don't know whether we will work out any system. It would take a much more expensive program than we can afford at the present time to contact office buildings and educate them to discontinue or take the rubber bands off before they discard their cards.

I might tell you something that is even more serious than that. In the last few years a tabulating card has been developed that's made of plastic, and it looks exactly like a paper card. We are working on that now. I hope that we can somehow arrange to have a distinctive mark on these products. Next month there will be a session on the problem with the manufacturer; but we are going to try to stop that at the source—not that we can stop the manufacturer of the plastic tab cards, but we may be able to arrange it so that it can be easily distinguished.

But educating all of the millions of office workers in the country is quite a chore.

Chairman Renegar: Well, Ralph, don't you think that the wastepaper dealer has some control over the tab cards—the rubber bands and paper clips and other foreign debris that get in there? If he refuses to buy it, the people who put the rubber bands on there can't sell it.

Mr. Kumler: Yes, I think so. He will refuse to buy it, if the mill refuses to buy it.

Chairman Renegar: Ralph, you made one statement, that what one mill won't use another mill would, and that the wastepaper dealer is a little bit confused because supposedly the buyers do not have a continuity of thought on what is good wastepaper and what is bad. I think there is one thing that a wastepaper dealer fails to realize, that all mills do not produce the same kind and quality of boxboard, and the result is that, what one mill would consider inferior wastepaper would be perfectly all right for another mill to use. I think probably the wastepaper dealers are not taking into consideration the quality of boxboard which is being produced by the mills to which they supply the waste.

Mr. Kumler: Correct.

Chairman Renegar: Is there anything being done along those lines, so that the waste dealer can be better acquainted with the various qualities that we are trying to produce?

Mr. Kumler: Well, I don't think we have gotten to that point yet. We are trying to keep out of wastepaper the things that nobody wants. When you get into the question of what one mill can use and what another mill can use, their situations are so numerous and varied that it is a little bit beyond us to handle.

Chairman Renegar: Thank you, Ralph and Jim for a very excellent review, and I am quite sure that if any of you have any further questions after this session that may occur to you, if you will contact Ralph, he will try to enlighten you.

Our next paper was on wastepaper cleaning and refining. I don't know of any company in the country which has spent as much time and effort, and been so successful in cleaning up wastepaper as Gibraltar at North Bergen. That paper will be reviewed by P. S. Bolton, of Robert Gair.

P. S. Bolton: In review of this paper, I have attempted to do two things: one, to realize that this cleaning system was designed for a specific purpose, and to make allowances for that, possibly to make allowances for compromises that we all have to make sometimes when we would prefer not to.

On the other hand, I feel that perhaps some of the theoretical considerations might be worth discussing, and I have attempted to follow the outline of the paper with comments on each of the steps.

The first one, of course, is the location of the centrifugal cleaners, and I am pretty sure that this was a compromise, in that the vortraps were put in right after the hydro. At least 5% of the stock was not defibered at that point. If you expect to get maximum efficiency from any centrifugal cleaners, you must be completely defibered at that time. The more stock you have that is not defibered, the less efficient your vortraps are going to be.

The breaker trap, of course, has rather close clearance, and if any of you have looked this paper over, the one thing that will really hit you right in the eye is that it takes 325 hp. to defiber 8 tons of stock per day, which is, to my way of thinking, a lot of horsepower.

Now, I go along with the idea that you can get much greater efficiency out of your refining equipment if your stock is thoroughly defibered, but I am not at all sure that you need that amount of horsepower to do your defibering. As a matter of fact, we have some test figures that indicate that we could handle that 8 tons with 75 hp. and have it completely defibered.

The screening—there again I would rather see a finer screen and a larger amount of rejects, but of course that presupposes that you have some way of handling your rejects. Nobody has made to much effort to handle rejects from screens, and I think part of that is due to the fact that the screen people have given up. If you try to buy a screen, they quote you on capacities based on virgin pulp. Then you put wastepaper through it and get 25% of as much as they said you would get. The next reaction of the screen man is, "Well, you have a $^1/_8$th-in. hole and you can't get 50 tons through the 8th inch, so let's put in a quarter-inch hole. This doesn't seem to me to be the right answer to a cleaning operation.

There is no great argument that secondary screening is not necessary if you want to get reasonably clean stock. You aren't going to do it with a $^3/_{16}$th or $^1/_8$th-in. hole in your primary screen, and I like the idea of using the Bauer cleaner but I am not sure the Bauer cleaner will be a solution.

I don't know that I like the idea of taking the rejects from your secondary screens and putting them through $^5/_{16}$ holes. You have closed circuit, and you are running them round and

round and round until they are broken up. You have slotted plates on your Vibrotor screens, and you take them out and put them back in the system, and the only place they are going to come out is right on the same Vibrotor screen.

I would like to ask one question in regard to these Vibrotor screens, and that is in regard to their upkeep. Do you find that you are having too much service cost on those, or haven't you run them long enough to know?

JOHN VERWAYEN: Well, we have had the Vibrotors for over a year—one almost 2 years now—and, true, there is maintenance on it, as with any other piece of equipment. As you say, you have to make compromises, and that is one of the compromises. You have to spend money to get something. You have to spend money to keep them in shape to get what you want, but I wouldn't say that the maintenance is excessive.

MR. BOLTON: In summing up, this approach, to my mind, is the proper approach. You have set up a system. You haven't done it by bits and pieces. You have a system here for handling two of your fractions, your heavies and lights, and they are tied together. They are synchronized. It is not just patched together. That I like.

So far as the refining is concerned, I am going to duck. I don't want to get into that. My feeling is that it isn't so much the equipment as how you handle it.

CHAIRMAN RENEGAR: John, would you like to reply to any of the statements that Phil has made?

MR. VERWAYEN: On the first statement the location of the Vortrap is really a compromise. It would be nice to have them ahead of the breaker trap, and also have another set further down the line where the stock is perfectly clean and defiberized, but there is a compromise on money. However, we feel that by putting them ahead of the breaker trap we save a lot in maintenance on jordan fillings. For instance, we do not get any sand in our vats now. We used to put in a set of jordan fillings every 3 months, and at that time we had only 150-hp. motors. We put on 350-hp. motors, and we get 18 months' life out of the fillings so that alone probably pays for and maintains the Vortraps. They always take money to maintain, but it is worth it.

The breaker trap uses 300-hp.—a little better than that, but the actual power consumption in the beater room before and after the breaker trap is the same, so we actually get the power that we put in the breaker trap for nothing because we take it away from the refiners and jordan. In other words, the breaker trap prerefines, so you do not use any more overall power, and all the stock goes through the breaker trap.

MR. BOLTON: I realize that, but it is 8 tons you are handling.

MR. VERWAYEN: No, we prerefine 160 tons in the breaker trap and of course we have the advantage of not screening. There is more intimate contact with the fiber not going through in big flakes. I do not understand your statement of the 8 tons.

MR. BOLTON: You said 5% of your 160 tons.

MR. VERWAYEN: It all goes through the breaker trap.

MR. BOLTON: I realize that, but there is only the 8 tons concerned that would not pass the screen.

MR. VERWAYEN: No, the main reason we put in the breaker trap was that we could use Vibrotor screens, because all the stock has to go through 20,000 slots. If you have a lot of big flakes, you do not get it through.

MR. BOLTON: You have a series of screens ahead of your Vibrotor screens?

MR. VERWAYEN: Yes, with $^3/_{16}$-in. holes, and I agree that is too large, because the smaller they are the better.

Now, the other question, it is true that we have large holes on the Selectrap, and still, of course, we get all the floating trash out, but we do not just recirculate it because the rejects from the screens go to the Bauer refiners. There are two primaries and one secondary, and the rejects from the secondary are discarded. There is where you get it out. All the accepted goes through the Vibrotor slots.

MR. BOLTON: The rejects from the Vibrotor screen have already been through your first screen?

MR. VERWAYEN: Yes.

MR. BOLTON: If you put them back into your system, they are going right around to that secondary screen again, and they are going right through it again, aren't they?

MR. VERWAYEN: Well, the rejects from the centrifugal screen go through a defiberizer, and then to the Selectrap. Of course, in the Selectrap you throw out a lot of rejects too, and they are discarded. You have holes in the Selectrap, and some of the accepts will contain floating trash that will circulate more than once. Is that right?

MR. BOLTON: Yes, that is right, but I still think that you are circulating a certain amount round and round until you break it up fine enough so that it is going to pass something.

CLETUS COFFMAN [Chesapeake Paper Board]: John, have you figured how much you actually throw away?

EDWARD MONOGUE [Gibraltar Paper Co.]: We throw away about 9%—about 8 to 11%.

MR. BOLTON: I would like to make one remark about that shrinkage. Everybody gets all excited because they see a little pile of rejects with some paper fiber in it on the floor. I do not believe that at the end of the year, if you add up how many pounds of stock you use and how many pounds of board that you make, that you can find the difference between what you did before and after cleaning. As a matter of fact, you fellows are losing more on moisture content every day than you will lose in a cleaning system of this sort. But when you can actually see it pile up, and you look at it, and it looks like quite a lot of stuff—

MR. VERWAYEN: But there is sand in it and cellophane, and you can't make a good sheet.

MR. MONOGUE: As far as using that, you could not justify it. There is no equipment that you could put on it to try to use the piled up rejects. Rather than try to save the stock, we dump it. We do not want it, in other words.

JOHN SARGENT [Central Fiber Products Co.]: Were there any other changes in your system that you might attribute the increased jordan life to other than the Vortraps?

MR. VERWAYEN: No.

MR. SARGENT: Even though you increased the horsepower 250%?

MR. VERWAYEN: That is right.

MR. SARGENT: You have increased the jordan filling life 600% due entirely to the Vortraps?

MR. VERWAYEN: Yes, because at that time we did not have the centrifugal screens. The Vortraps were one of the first things we put in; and by taking out the staples which are in old corrugated boxes, and glass and sand—I think that is the only thing that gives the jordan fillers longer life.

MR. WERDOUSCHEGG: Did you have any experience on rotary screens instead of flat screens?

MR. VERWAYEN: No, we don't have any rotary screens, except the Vibrotor screen, which is similar to a rotary screen.

CHAIRMAN RENEGAR: Thank you, John and Phil, for a very interesting presentation.

Our next paper which was presented this morning was the "Use of the Asphalt Dispersion System on Wastepaper."

To the best of my knowledge, this is the first time that a paper ever has been presented to a group such as this on an asphalt dispersion system. It was presented by Jim Higgins, of Ohio Boxboard, and will be reviewed by Paul Trout, of Waldorf Paper Products.

PAUL TROUT: I appreciate the privilege of reviewing Higgins' paper on the asphalt dispersion system, particularly because the company I represent was one of the first to use the asphalt dispersion system.

Waldorf Paper now is operating five units on various grades of board. The main points that Mr. Higgins brought

out were, first, that the system was devised and is patented by the Fiber Conservation Corp., having as its primary aim the improvement of the appearance of reclaimed fiber furnishes. Secondly, that the process was arrived at after a study of various other methods of asphalt removal or disguisement; namely, solvent extraction, solvent emulsion, and addition of diatomaceous earth, or other filter materials.

He also presented some basic operating data which will be helpful in estimating space, equipment, and costs, some of these being area required of 1000 to 2000 sq. ft., steam consumption of 1500 to 2000 lb. per ton, power consumptions of $2^1/_2$ to 4 hp.-days per ton, steam pressures in the 60 p.s.i. range.

Alone this line, as base points, I might say that our own operation shows slightly higher steam consumption than those cited, and slightly lower power consumption.

One point which was not brought out too clearly was the range of asphalt contents normally encountered. In our own case this ranges roughly from 0.3 to 1%, by the way.

The fourth point brought out was the flow diagram of the system. I am sure you realize that this is fairly flexible, in that, although he showed two stages of thickening, it is possible, perhaps, to accomplish both thickening stages in one operation. Instead of going to 15% on deckers and then up to 30% by pressing, perhaps you can do the whole thing in one step.

The flow diagram involved thickening pressure, and the third stage being discharged and subsequent quenching with excess wastes.

A few other operating points from our own experience: we found that the consistency into the feed screw entering the preheater chamber is important. We found that if the stock is too wet, we have an overload, and we throw out the feed screw motor. As a result, we normally operate well within the range mentioned.

Secondly, we found it critical to have the disks on Asplund defibrator maintained; otherwise we get higher wear and poor asphalt dispersion.

We also find that the higher steam pressures give better dispersion, as you might expect, particularly with the higher melt point asphalts. It is necessary that you raise your temperature above the softening point of asphalt.

Some of the other points may be somewhat controversial. We feel that the system aids defibering of the stock. For example, in some cases with wet-strength stock we may find a few clumps, and we find that the system is helpful in eliminating those. We do not find that it helps us particularly on the adhesive rubber materials or the synthetic case-sealing resin adhesives.

We have found the system permitted our mill to eliminate the top liner in our test liner machine, and consequently we can run a solid sheet at the present time.

Those are about all the comments I have. I would like to ask Jim two questions. I would like to ask him to comment first on the effect of the system on strength development. Does it harm or help the strength of the stock? Secondly, I'd like to ask him what happens to the asphalt. Is there any possibility of a build up in the system as there might possibly be with some of the solvent types? And he might also commment briefly on operating costs, if he would.

Mr. Higgins: With regard to this strength development, or the question: is there any effect, we have made several studies and are acquainted with several studies made by other companies that are operating the unit, and as yet we do not find that it affects the strength. There are several who say they can see no effect before and after they put in the dispersing unit, and there are a number who definitely would say that it helped strength development.

After all, it is a refiner, and it gives you a chance to prepare the stock much as John mentioned. The breaker trap gives you the effect of actually separating individual fibers, and therefore the refining equipment you have can do a better job.

In another study we have made, we have taken stock before and after the asphalt dispersion system, and run freenesses and made handsheets in the laboratory besides actually studying the finished board. We find that the samples taken directly out of the dispersion unit would appear to have lost strength and the freeness had increased some. However, with refining, the strength comes back, so it is a matter of a temporary loss, or appearance of loss.

With regard to what happens to the asphalt, the asphalt dispersion process is that type where you really disperse the asphalt. The asphalt stays with the sheet. You do not separate it and have a waste problem. The particles are present in the sheet, as contrasted to the experiments which were run some time back on extraction. In this approach to the problem you clean the sheet and when the amount of asphalt is checked, it isn't present. It is in the water system somewhere, and you probably are likely to run into a problem when it builds up to a certain concentration.

Now, with regard to costs, as I mentioned this morning, some mills have required additional labor. In the case of our mill, we took a man off when we installed the unit. We were able to consolidate systems, and we actually eliminated manpower.

Equipment costs—an installation of around $125,000 is good for about 75 tons which is in the neighborhood of 35 to 55 cents per ton for your capital investment.

Repairs have varied quite a bit over the years that the system has been in operation, and there were a lot of problems with the first equipment that went in some of these installations. It was an entirely new system, and the people had to learn how to operate them. We had very high repair costs for some time, although now I think a figure of 50 cents a ton would be quite reasonable. Some report more, and some report less, but that would give you a bench mark, somewhere in that neighborhood. The more development you do, you may run into more labor costs, because the more complicated you make the system, the more chances there are of failures, and more repair work that you will encounter.

Steam will vary pretty much with the individual mills. As Paul mentioned, somewhere between 1500 to 2000 lb. per ton has been reported; and power, you can estimate $2^1/_2$ to 4 hp.-days per ton.

I think those are most of the cost figures that you would assess. You may have a figure you would want to assess for the floor space, but that is up to the individual mill. If you have to build another building, that is a bigger investment, and there would be more cost in that respect.

Mr. Crawford [W. R. Grace & Co.]: With reference to the digester, your Asplund feeding screw, and your disk defibrator, I wonder if you could give us an idea, assuming that you are operating at a certain level, 100%, 75%, 50%—whatever you may choose—how often do you repair or replace the defibrating disk and the feeding screw?

Mr. Higgins: I am sorry, I cannot help you too much on that. Ed Spence, our chief engineer, was going to be on the program, and I didn't dig those figures out, because I thought he would be here and could answer questions about them. He was not able to make it because of the weather conditions.

Jim Stimson [Gaylord Container]: We have an Asplund dispersal system, and in answer to his questions on changing the Vibrotor plates, two months is about the limit that you should run. Now, the screw feeder system is another question. That is the most expensive repair item that you have, and we find that in about 3 or 4 months we have to change it. Even though it is stainless steel it wears off very rapidly. This may be a boost to the defibrator people, but I think it is one of the greatest things that has hit the paper mills in the last 4 years.

Mr. Cushman [Alton Boxboard]: What is the size of the unit?

Mr. Stimson: We have the large size unit capable of about 180 tons.

MR. CUSHMAN: Our experience at Alton was a little different from that. I don't have the figures at the tip of my tongue, but, roughly calculating, at about 18,000 tons it is necessary to replace the compaction screw, and at about 4000 tons to replace the wear segments.

MR. STIMSON: Is that the screw feeder you are talking about?

MR. CUSHMAN: The compaction screw.

MR. VERWAYEN: Is it true that if you run, say, a 9-pt., or test liner, that you get a lower test because of the asphalt dispersal, and also, do you get more shrinkage?

MR. HIGGINS: I do not know about the strength on 9-pt. I have no experience on that at all, but with regard to the shrinkage, there has been some reported by some of the mills. Their shrinkage, in respect to the width they were able to trim, reduced 3/4 to 1% with more work on the stock, it would shrink up. I am not sure about the strength on 9-pt.

MR. STIMSON: On 9-pt. I have found that we get about 4 in. shrinkage using the dispersal system.

CHAIRMAN RENEGAR: On what trim?

MR. STIMSON: This machine is 130 in. trim, and we get about 4 inches.

MR. HIGGINS: That's a bogus furnish, yes.

MR. TROUT: In our operation we don't find a shrinkage. If there is any, it is insignificant. Again, that falls in the same category as strength development. Some people say yes, and some say no, and some say, "I don't know."

MR. HIGGINS: Well, in our case I know that we reduced the weight considerably. At the same time we were able to speed the machine up about 40 ft., actually more than that, and reduced the weight 4 or 5 lb., we noticed some reduction, roughly 1%. Now, whether it was due to the dispersion unit, the higher speeds, and the lighter weights is a question. We know that lighter weights are going to have greater draw shrinkage as to that aspect alone.

MR. STIMSON: Jim, what specific weight are you running?

MR. HIGGINS: We were running 54 to 55, and we now run in the 50 range—51 or 52.

MR. STIMSON: I do not find too much loss in bursting strength, and sometimes I gain. I think that is the variation in furnish, if you are talking about jute lined.

MR. HIGGINS: I think that's true.

MR. STIMSON: And also, it does help the bogus sheet too.

MR. KUMLER: I want to ask how you take advantage of this equipment. Do you process all stock that might possibly contain asphalt, or just what you know contains asphalt?

MR. HIGGINS: We no longer run a clean liner to try and cover up.

MR. COFFMAN: Have you run this system on anything except whole kraft, like on mixed furnish?

MR. HIGGINS: We have run some, and I think Paul has run quite a bit on that type of furnish.

MR. COFFMAN: Do you find any change in the characteristic of your fiber, running through this Asplund?

MR. HIGGINS: We were running chip liner, and we didn't see anything there. We weren't checking too much on those lines.

MR. TROUT: In our own company that is quite controversial. There are two schools of thought. One faction feels that it helps some of the physical properties of the finished board—stiffness, etc.—and then there is the other school of thought that says, "You haven't proved it to us yet."

MR. HIGGINS: With regard to stiffness, if we are going to make a soft sheet, we do not use the dispersion unit. We feel that you tend to get a stiffer sheet.

MR. STIMSON: I am making a chip sheet that we used to make with a news liner, and now we are making it with a chip liner and it looks better.

This afternoon we had the pleasure of listening to a very interesting and highly informative paper on the progress of the Stevens Vacuum Former. Originally, Brookover, of Dowingtown Paper Co., was going to present a review, but he called me that he too had troubles with the Pennsylvania Railroad and was unable to make it. So at the last minute I asked Fred Barber of Diamond Gardner to pinch-hit for him, and I know he has a whole stack of notes from which he will make his comments.

FRED BARBER: Certainly, practically all of us are caught in the cost-price squeeze, and so we are keenly interested in any possible savings that we can make in our operations, and we're also extremely interested in any better formation possibilities which Bill touched on. He mentioned that for at least 25 years there has been keen interest in the possibility of doing something with a suction-forming vat like the Stevens. Perhaps some of you know that Diamond Gardner has been interested in this type of vat for quite some time, but I'm sorry to say that I'm not at liberty to discuss it in any detail, so we'll have to stick to questioning Bill on his particular type.

Then, of course, as he pointed out, in the last 5 years there has been extreme interest and activity along the line of this type suction-forming unit. He brought out that, they had to learn a lot of new things and get a whole new concept of accelerated formation on cylinder.

He mentioned something of interest to most of the practical fellows in the room, that it was a real tough job getting from what they could show on paper would do a good job over to what was a practical operation on the machine. This strikes a sympathetic note with most of the operating people here.

The he went on to list some practical installations of the unit that he discussed, and these seemed to break down into two types. One was the cylinder mold type, which has, the air pressure loaded headbox.

A very interesting point that he brought up was that they feel that they can get a one-to-one ratio in the formation results they get with that type vat, and that seems to me a very uniform formation for a cylinder machine.

He mentioned that this cylinder mold type has been included in what they call their packaged tissue machine, and there are three of those in use at the present time.

As far as the conventional-type cylinder and paper board machine, it's certainly being used in one installation for underliner and top liner, and then there is another machine in the works—I don't recall whether he said six or seven cylinders—on which it will be installed on each vat position. Here they run at speeds of 300 ft. and they expect to be able to run as high as 1000 ft. a minute.

The other type is the type that has the separate fourdrinier wire, and he hopes to go up to 600 ft. and even higher on that. However, there are none of those on a commercial basis at the present time.

He touched somewhat briefly on the large amount of experimental work that was necessary in the development of this vat, breaking it down into seven areas. Without trying to go into any detail, he spoke of the area of turbulence, that of flocculation, fiber retention, fiber orientation, filtration, resistance, and mat stability; no, there was still a seventh one—dynamic drainage—and I am sure that there will be quite a few questions on the extent and progress so far on those particular areas.

Then something that would be very interesting to the person who is interested in getting into this type of vat was they will soon have a pilot plant available, and should be able to produce most any type of sheet with it that can be produced with this type of equipment.

I would like to thank Mr. Goodwillie, and the one question that comes to me—and it is pretty broad—is that he didn't say anything about costs of these units, and what some of the possible savings might be in using them.

MR. GOODWILLIE: On the matter of tensile strength, I got a little bigger hand on that than I anticipated, because

one-to-one is a theoretical figure. We have approached one-to-one on some runs under certain top liner conditions. We have actually seen tests reported at 1.1-to-one. A great deal of operation has been in the range of 1.5-to-2.5, depending upon the type of sheets, and so forth.

It is rather difficult for us to stand here and try to answer a great many questions about cylinder machine operation in detail, as much as anything else, because when you have a unit in a multiple vat machine and you want to do some testing, and you want to get some samples, and you want to break down sheet and you want to do a lot of funny things, the fact that you have got all those other vats pumping stock down toward the liner end makes the operators just a little cautions about letting you do all the tricks you want to do. For that reason much of our data is from machines making a single sheet.

I don't think I can give you anything concrete about the costs of these units. They cost more than conventional vats. I wonder if you would be willing to accept that answer.

Chairman Renegar: Is your pilot plant to be a full-scale model? Would you mind talking a little bit more about the vat in your pilot plant?

Mr. Goodwillie: We are developing this unit, which will not look like a conventional unit when we are through with it, because it is built to have the utmost degree of flexibility. It will make a sheet of approximately 18 in. width, so that we can throw away some side parts and have a center of a sheet that should be representative of what we are doing. We do hope that we will be able with that unit to reproduce operating conditions on a wide variety of machines, and come up with a sheet that has been formed at machine speed—that is, any speed we are interested in, from the very slow speeds up to perhaps 2000 ft. or better on the lighter weight sheets. It will give us an opportunity to vary consistencies and vary the relationship of stock and water velocity, and all the other things we will want to play with, ending up with a handsheet that can be dried and tested for all its strength characteristics, as well as its appearance and all other characteristics.

So we will not have a machine that will run and roll up a big reel of paper. We will have a machine running under circumstances so that any number of handsheets for study can be taken off. We expect, if we are successful, that we will be able to get the end sheets out without disturbing them unduly; in other words, trying to bring the sheet away, for example, in the same condition that it was on the wire after the formation period.

Question: Mr. Goodwillie, I realize that in a commercial installation it is hard to get the specific data, but what is the heaviest weight sheet that can be picked up?

Mr. Goodwillie: Our experience today isn't very complete in the heavyweights, but we have had some experience running with a sheet that on the paper basis would be in the 70 to 80 lb. weight.

Question: Is this vat operating at conventional consistencies, or higher or lower?

Mr. Goodwillie: The tendency is for these units to operate at lower consistencies than conventional. Now, we suspect that it is somewhat in the category of equipment in a mill and in the hands of the papermaker who traditionally feels that if a little water is good, that a lot of water is better and he can usually prove it. [Laughter] So the consistencies have been quite low.

To give you the range on very light weights, on tissue grades we have seen quite a little operation where the headbox consistency would be 0.1, and as we go to heavier weight sheets we have seen operation-where the headbox consistency would be from 0.25 to 0.3. The tendency is for low consistencies for it seems to give you a much better formation.

Mr. Crawford: In regard to squareness of strength, you mentioned a 1.5 to 2.5, which on my slipstick comes out to 80% in one direction, as compared to 100 in the other direction. I think that is quite possible to do this with some of our other vats, not strictly conventional, but if you push it you can get it anyway.

Mr. Goodwillie: I do not think I get the full implication of your question. Maybe you would like to make one more comment.

Mr. Crawford: What I mean is, if you push it, you can get cross-formation on the mold any way.

Mr. Goodwillie: Yes. That is common experience on multiwall sacking machines.

Mr. Crawford: Right.

Mr. Goodwillie: [Continuing] . . .where they run a little faster than the wire, in order to get the best relationship across and with the machine direction.

Mr. Crawford: You can do it on a cylinder mold too.

Mr. Goodwillie: The common experience, however, if you get out of what some of us think of as the specialty cylinder machine operation, and you get into the big producers—the general tendency for those machine is to show a one directional strength situation, and we do hope as we go along that there will be all kinds of developments in accelerated formation and better controlled formation which will give the cylinder board people the opportunity to make really high quality formation without speed limitations. That is the dream, and it does seem as though we are getting there.

Mr. Crawford: Mr. Chairman, I yield to the gentleman's argument, when you have to make tonnage.

E. N. Glauner, Jr. [Pusey & Jones]: Has it been found necessary to use vacuum pickup for the common application of a plain two-ply?

Mr. Goodwillie: We have both types of pickup in our operation. The arrangement that will have the widest use in the near future on the multiple cylinder machine will involve a plain pickup. We have operated for periods of time with plain pickup. There are some advantages in using a suction pickup roll, and predominately on the lighter weights and the higher speeds, we are using a suction pickup, and on the multiple cylinder machines, the plain.

Mr. Verwayen: Could you comment on the amount of vacuum you carry inside a mold?

Mr. Goodwillie: That varies quite widely, depending upon—well, quite a few factors.

The lowest condition we have had in regular operation has been down to a point where it's just 2 or 3 in. of water. The largest negative we have operated with so far in regular running has been somewhat in excess of 30 in. of water, not mercury, of course. There is no reason for a limitation at that point, and it is probable that as we go up into higher speed ranges, those negatives will be greater.

I see that sigh goes out from down there. Our 30 in. of water would be a little over 2 in. of mercury.

Mr. Trout: What is the diameter and face of the cylinder on your experimental machine.

Mr. Goodwillie: Thirty-six inches in diameter, and enough wider than 18 in. so that we can be sure of picking up an 18-in. sheet.

Mr. Higgins: Is there any problem in keeping the cylinder face clean, since you have such a small area, and you are continually sucking on it?

Mr. Goodwillie: Where we have the wires on the mold structures so that we have a unit that we can think of as being very similar to a cylinder mold, we have the old problem of picking up material, particularly when running on reused paper stock. The common arrangement with that type of device would be to have two showers, one a full width shower, and the other a traveling jet shower for high pressure. Practice varies a little bit from one place to another, but I would think of it this way, that the high pressure traveling jet shower would be operated intermittently, perhaps for a short period in each shift, and its suction, of course, would dislodge the particles of foreign material embedded in the

wire. The full width shower is operated continuously in some instances, and very intermittently in others. The unit has shown a gratifying situation as to cleanliness on the inside structure of the mold itself, such that with rather intermittent use and not too much heavy showering, it seems to keep itself very clean.

Our real problem, as you would expect, is with any foreign material imbedded in the surface, and to date our best answer is the high pressure traveling jet type of shower.

MR. HIGGINS: What pressures are you talking about there?

MR. GOODWILLIE: The high pressure shower—I suppose the operating pressure would average out somewhere around 600 to 700 p.s.i., and there would be perhaps one unit for every 40 or 50 in. of sheet width.

MR. BARBER: When will the multicylinder machine be in operation?

MR. GOODWILLIE: That's a leading question, but I hope within 2 months' time.

MR. CRAWFORD: I am somewhat confused in regard to the pressure of this shower. Will you restate that?

MR. GOODWILLIE: Well, a full width shower would be installed, and the traveling jet shower. The full width shower would probably be set up to operate with perhaps a maximum of 125 lb. pressure, and depending on the nature of the operation it might be operated with the valve fully open, or partially. The other shower is a jet shower which can either be a straight nozzle, so that you have a straight round jet impinging on the wire, or in some instances a fantail jet arrangement to give a wide flat stream; but in every instance there are only a few of those nozzles in any unit.

If it were, let's say, 100 in. width, just to take a unit, there might be two nozzles and they would be arranged so that they would somewhat overlap at the center, but would travel across.

MR. CRAWFORD: The pressure, though?

MR. GOODWILLIE: Nominally, 1000 lb. but at the jet itself usually that is some 60 p.s.i. of water pressure.

MR. CRAWFORD: It is a tremendous amount of energy. If it is not a fan shower, it has the ability to cut.

CHAIRMAN RENEGAR: Would you care to comment on wire marks in the making of high folding boxboard? We are constantly fighting wire marks, and I just wonder if you can comment as to whether there has been any increase in wire mark, or whether it's less over conventional-type cylinder molds.

MR. GOODWILLIE: I don't think I can give a very complete answer on that. I suspect that our wire mark situation is not going to be particularly better than it would be on a conventional unit. Our experience with these units sort of ties in with the general experience on ordinary machines. We can get along with moderate wire mark under some conditions, and in others you have a very severe wire mark.

The condition that seems to produce the strongest wire mark is an operating situation requiring a very high differential in pressure, meaning that the mat is compacted down to the wire very severely, and what we try to do is to design the situation so that our rate of formation can be low enough, and our other sets such that the pressure across the wire may not be extreme, and that way we hope to get along with satisfactory wire marks.

We are not in a position to claim a big advantage.

CHAIRMAN RENEGAR: Are you at liberty to state what mesh of face wire has been used?

MR. GOODWILLIE: I would like to tell you, but I'm not entirely clear in my own mind that I can remember precisely. I think we have had some operating experience with 50 and with 70-mesh wire.

MR. GLAUNER: You are forming a sheet by use of pressure and vacuum. After the sheet is formed, the combination of pressure and vacuum—will that mold reject what is left over? Will it reject anything superfluous put on to the mold?

MR. GOODWILLIE: I think maybe I can answer the question to your satisfaction this way, by saying that the unit operates in a manner that you can think of as similar to a fourdrinier, in that the pressure in the headbox is largely converted into velocity at the start of the forming area. That is the point that you can think of as being comparable to the slice of a conventional fourdrinier machine, and all the stock and water —substantially all the stock and water, and in most cases all —that passes that point is going to be formed into the sheet.

On some of the applications, particularly on some of the lower speed cylinder machine operations, there is a moderate overflow from the leaving end of the top, which is the end of the nozzle formation area, but that degree of overflow is very slight. The amount of stock and water that passes the flow is substantially all destined to pass through the wire and to form the sheet. For that reason it isn't as though you had a conventional vat with a bit space around the mold, and an overflow, and were overflowing a substantial amount of water away.

I think I can make the statement about freeness or consistency by saying that we would have something quite close to the general type of relationship that we have in the fourdrinier machine, where if you made the stock very slow, you would have to take water out, and if you freed up, you would have to add water to the flow.

QUESTION: Have you any experience on the relationship between the two velocities of the periphery of the mold, and the velocity of the stock?

MR. GOODWILLIE: That has to be watched quite closely. There again it is handled in a manner quite similar to that which would happen on a fourdrinier machine. On a fourdrinier machine, you would be accustomed to seeing a certain pressure behind the slice for a certain type, and it would vary slightly depending on how you were handling the sheet on the wire. We would have much the same situation with the suction equipment, in that there is a relationship between the pressure in the headbox and the machine speed. There you come to the question of whether or not you want to adjust for as close to a one-to-one ratio as possible, or you choose to go farther away.

CHAIRMAN RENEGAR: Do we have any more questions? [No one responded.]

Well, gentlemen, I think this has been a very interesting day for us.

MR. CRAWFORD: Mr. Chairman, I wonder if it would be out of order to ask one or two questions of the other speakers.

CHAIRMAN RENEGAR: This is your meeting.

MR. CRAWFORD: With reference to the soluble tapes for joining rolls together, I investigated them some time past and found that those that I investigated had quite a short shop life, less than 30 days. I am wondering whether or not anything has been done within the last 2 years, since I last investigated them. They may have a longer life now.

MR. KUMLER: What do you mean by a "short shelf life"? What happens?

MR. CRAWFORD: I was assured by the people who sold them that they would not be good after 30 days.

MR. KUMLER: There is only one manufacturer that I refer to, and they did have some trouble at the beginning. If you haven't investigated within 2 years, I would suggest you look again, because they have made some progress.

CHAIRMAN RENEGAR: Well, this concludes our afternoon session, gentlemen. I think we all owe our thanks to the panel members and the authors of these various papers who have spent so much time to prepare these interesting subjects for our enlightenment. With that I would like to adjourn this session, and hope to see you all back next year. As I understand, I am still chairman, and we're going to try to do better than what we have previously. Thank you.

LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel, and Events

Delaware Valley

A penetrating comparison of conical and disk-type refiners was presented at the November 21 meeting of the Delaware Valley Section of TAPPI. About 75 paper industry men attended the dinner meeting in the Engineers' Club, Philadelphia. The featured speaker was A. J. Felton, executive sales engineer, Shartle Division, Black-Clawson Co.

Mr. Felton approached his subject—"Conical Versus Disk Refiners—Theory and Mechanics"—with an analysis of the two types of refining engines—how they are constructed, the reasons for their design, and the limits of the results obtainable with each. He then revealed tabular data from first-hand surveys of many paper and board mill stock preparation systems where power comparisons were possible among all-conical, conical and disk combination, and all-disk systems.

From the data, Mr. Felton was able to make pertinent observations about the selection of refining equipment, suggesting that new combinations of conical and disk refiners may improve refining efficiency for some mills.

In charge of the meeting was Section Chairman Don C. Kane (Hercules Powder Co.). Mr. Felton was introduced by First Vice-Chairman George K. Boger, Jr. (Amalgamated Chemical Co.) who is responsible for programs.

Lake Erie

On Thursday Dec. 18, 1958, the monthly meeting of the Lake Erie Section was held at the Cleveland Engineering and Scientific Center. The topic discussed was "Foil Lamination"; the speaker was James Trousdale of Cochran Foil Corp.

The next meeting of the section will be Friday, Feb. 20, 1959, at the Cleveland Engineering & Scientific Center. The topic which will be discussed is "Printing Processess."

DENNIS HEINDEL

TAPPI Delaware Valley. Guest speaker A. J. Felton of Black-Clawson explains performance curves of conical and disk refiners to officers of the Delaware Valley Section of TAPPI. From the left are: Secretary Henry Smaine (P. H. Glatfelter Co.), Mr. Felton, First Vice-Chairman George Boger (Amalgamated Chemical Co.), Chairman Don Kane (Hercules Powder Co.)

Aluminum Foil—Laminating, Coating, and Printing

James T. Trousdale

THE production and use of aluminum foil in this country is continuing to grow, having more than doubled since 1952. In 1955, foil producers shipped 203,081,490 lb., over three fourths of which was used in packaging. Today, there is every indication that foil will continue to be a strong and growing factor in packaging. The acceptability which foil has attained may be attributed largely to its versatility, usefulness, and attractiveness, as well as the relative ease with which it has been adapted to existing conversion equipment, particularly in the graphic arts field. For it is in the printed form that foil enjoys its most widespread usage.

In some special instances plain, unsupported aluminum foil is printed on directly, but, generally speaking, it is the laminations of aluminum foil to paper or paperboard which concern the printer. It is our concern to tailor-make these laminations to perform the specific job in question at the least practicable cost.

In the laminating of aluminum foil the most popularly used alloy has a minimum aluminum content of 99.45% and is identified in the industry as alloy 1145 or "foil purity." Aluminum foils for laminating range in thickness from just under 0.006 to 0.00025 in.

MANUFACTURE

Foil comes from the rolling mills in a hard temper, having a light film of rolling oils on its surface. Since, for laminating purposes, the foil must be soft, this hard foil is annealed by heating at temperatures of 800 to 900°F. for 12 to 14 hr. This process not only makes the foil soft but also removes the surface rolling oils.

Foil in thicknesses up to and including 0.001 in. is generally available with one shiny surface and one dull (or "matte" or "satin") finished surface. This results from the practice of rolling two layers of foil together. The outer surfaces are polished from contact with the rolls and the dull surfaces result from being in contact with one another. Thicknesses heavier than 0.001 in. are shiny on both sides.

There are a number of properties responsible for aluminum foil's usefulness as a packaging and labeling material. The most generally recognized of these, and one of foil's main attributes, is appearance. It use for point of purchase eye appeal is unexcelled and a wide latitude of decorative effects can be obtained through embossing and coloring. Also, foil is hygienically clean, all of the microorganisms having been destroyed during the annealing operation. Since foil is nontoxic, it may be used in direct contact with many types of goods. It has no taste or odor, thus lending itself to packaging of the most sensitive of foods, such as cheese or butter.

Soft foil has "dead-fold" characteristics which enable it to be crimped and folded easily, and it will remain completely flexible throughout a range of temperatures far surpassing that required in most packaging applications. The extremely low moisture permeability rate of aluminum foil and aluminum foil laminates is a decisive advantage in packaging. Foil 0.0015 in. thick and over is conceded to have zero perme-

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JAMES T. TROESDALE, Cochran Foil Corp., a subsidiary of the Anaconda Co., Louisville, Ky.

ability, but even in thicknesses as low as 0.00035 in. the transmission rate is negligible. Foil is nonabsorptive to liquids and completely greaseproof. It offers protection against ultraviolet rays and provides a gas barrier in certain types of packaging.

Other important properties of aluminum foil are its heat conductivity and reflectivity. It reflects up to 96% of radiant heat and emits as little as 4%.

LAMINATING

In the laminating of aluminum foil, combinations of any of the various gages of soft metal and papers from 12-lb. tissue to 30-pt. paper boards may be accomplished. The laminating is done in roll form, which calls for good bending characteristics of the paper stock, particularly in the heavier calipers of board. Another important consideration in selecting a paper or board stock for laminating is surface smoothness.

In most laminated materials, foil 0.00035 in. thick is used. Foil in this gage will conform quite readily to any surface imperfections on the paper or board stock and the very nature of foil itself tends to magnify these imperfections. For a foil surface that is to be printed, the ultimate in smoothness is desired; consequently, great care must be given to the choice of paper or board stocks.

As previously mentioned, the laminating of aluminum foil is done in roll form and is accomplished by unwinding the foil through a series of idlers and passing it over an adhesive applicator roll. This adhesive applicator roll, made of rubber, runs in contact with a steel fountain roll turning in the glue pan. The amount of adhesive applied to the foil is metered by the pressure between these two rolls. The foil then passes over a counter-rotating spreader bar where the film of adhesive is smoothed out and then into combining or nip rolls where it is joined with the paper or board stock. From here, the combined web passes to subsequent coloring, coating, and drying operations.

The adhesives used for foil laminating are generally of three basic types: (1) thermoplastic adhesives which are applied to the foil or paper and dried, laminating being accomplished by passing through hot rolls; (2) hot melt adhesives which are applied in a molten state to the paper or the foil and combined while still molten, and (3) water soluble emulsions and dispersed adhesive, applied by the same method. It is the third group of adhesives which have enjoyed the most widespread usage in the foil field. These adhesives may be starch, silicate, latex, or polyvinyls. Although we do not claim to be adhesive experts, we are familiar with the properties of each of these and how they perform; consequently, it is important that we have some indication as to the end use so that the correct properties may be built into the lamination.

COATING

After the foil is combined with paper or paperboard, the web then passes into the second station on the foil laminator. This station is essentially a gravure head utilizing an etched cylinder for coating. At this station the foil is coated or colored to produce the desired effect or to make it acceptable for one or more types of printing. Here again, in the case of foil stocks to be printed, it is desirable that the foil laminator know the type of printing to be done for different processes require different preparation.

From this coating operation the web then passes through a drying tunnel, where both the adhesive and the coating are dried, and is rewound into roll form at the end of the laminator. It may be asked, "Why is it necessary that the foil be coated for printing?" During the drying operation, a minute film of aluminum oxide is formed on the surface of uncoated foil, and in rewinding the foil surface would be brought into contact with the paper or paperboard causing further contamination as well as a polarity on the foil. Any of these conditions by themselves would be sufficient to prevent adequate ink adhesion; the combination makes it practically impossible without taking drastic steps through the use of acids in the inks. This, of course, is highly undesirable, and would result in severe plate damage.

In the case of gravure of flexographic printing, where the inks used are of a solvent type and need only to have this solvent removed to dry, we use a wash coating or treating which is in reality a microscopically thin film of shellac serving as a basis for ink adhesion. For foil printing by lithography, letterpress, or silkscreen, wherein oil type inks are used, we coat the surface of the foil with a nitrocellulose or vinyl-type lacquer. This film is applied at the rate of approximately 1 lb. per ream (24 × 36—480) or approximately $^1/_{10}$ to $^2/_{10}$ mil. This lacquer film serves a dual purpose. It provides a basis of adhesion and also gives a surface with which the oil-type inks may amalgamate to assist in drying.

We have been advised on occasions that various printers have been able to get satisfactory adhesion to uncoated aluminum foil laminations and have seen samples exhibiting excellent adhesion; however, results are not consistent and it is doubtful that any foil laminator will guarantee the printability of an uncoated foil surface.

In addition to the printability of the foil surface, various other factors must be taken into consideration when applying a foil coating insofar as the end use in concerned. The coatings used may be generally classified as decorative, heat sealing, and protective. Each type must have a good adhesion to the foil, and, since some may come into contact with food products, it is essential that they be nontoxic and free from odor or taste.

Decorative coatings which are to be exposed to sunlight must use colorfast dyes or pigments, rather than a fugitive type coloring which might ordinarily be perfectly satisfactory. Coatings requiring resistance to humidity or moisture must be specifically formulated for this purpose. This was an important factor in developing a coating for match book covers where perspiration resistance was of prime importance. Beverage labels in some cases require alcohol resistance and here the use of vinyl lacquers is preferred. There are cases where heat resistance is necessary to perform certain functions of packaging, such as heat seal labeling. All of these examples point out again how important it is that the laminator know the end use of the material in order to insure its proper manufacture.

Heat seal and protective coatings are applied in somewhat heavier films and are generally of a vinyl type, although other coatings are sometimes used, depending upon the specific type of resistance desired. In applications where resistance is to be an important factor, it is best to consider each application as a separate problem and select the coating material and the coating weight best suited to meet the special requirements.

PRINTING

The printing of aluminum foil laminations may be accomplished commercially by the gravure (sheet fed or rotary), flexographic, letterpress, lithographic, and silkscreen processes. The actual printing itself may be carried out most satisfactorily on existing equipment; however, special techniques should be employed to capitalize fully on the design potentials of foil.

Both transparent and opaque colors may be laid on foil (black and white, of course, must be opaque). Transparent colors printed directly on foil retain their natural illumination, whereas opaque colors appear much the same as they would on paper stock.

Two colors (two transparent, or one transparent over one opaque) may be combined to create a third color, thus making possible a vivid three color effect with the economies of two-color printing.

Reproduction of natural colors can be achieved using four-color process printing by gravure, letterpress, or lithography.

To do this, an opaque white must be laid down first and the process illustration printed over it.

Fine copy should not be printed directly on foil because the high reflectivity of the foil surface may render the copy illegible.

Restraint is necessary in using plain foil areas. Natural foil can be made an integral part of a design if it is skillfully broken up with opaque and transparent color elements. Interest can be focused on a particular part of a design by outlining an opaque area with natural foil. For instance, opaque printed brand names can be pointed up effectively by outlining the letter with natural foil.

Where white and gold are to be printed on the same label, overlapping will produce a buff color; consequently, it is desirable to leave a silver line between the two colors to avoid having this buff edge.

The design of a foil carton can have a very definite effect on the quality and price of the base stock necessary. If an overall pattern can be developed in the design either by embossing or printing, the smoothness need not be of prime consideration. Smoothness becomes important where large plain areas are present.

It is often desirable and sometimes essential that the finished piece be overcoated to protect the printed surface from scuffing or abrasion. This, then, should be taken into consideration with regard to design insofar as equipment facilities are concerned.

The advantage of any one type of printing over another on foil, as in paper printing, is primary determined by the size of the run; however, each has its points which should be taken into consideration. Generally, it may help to remember that the printing of foil is more closely related to the printing of glassine type papers than is the printing of glassines to printing on fibrous krafts or boxboard.

Gravure

Gravure involves two procedures; rotogravure, using roll-fed rotary presses printing from cylinders, and sheet-fed gravure, using sheet-fed presses printing from a "strap-on" printing plate. Rotogravure is particularly suited to long continuous runs on big volume packages or labels. Rotogravure, due to the fast drying inks used, has the additional advantage of extremely high speeds without danger of offset or smudge.

On the other hand, gravure cylinders and plates are more expensive than lithographic, letterpress, or flexographic plates and the time required to obtain them may be a deterring factor. Printing on foil by this process should be governed by the same criteria as paper insofar as the economics of run size and printing detail desired are concerned. These are, however, special considerations as to setup and handling.

Aluminum foil places certain restrictions on the gravure printer which should be pointed out to the engraver. The inks' inability to penetrate the foil surface means that viscosity control becomes more important. Uniform depth of etching enables the pressman to carry the ink at the critical viscosity which gives the best impression. It is not necessary to angle the screens for multicolor on foil, provided that all colors are screened at exactly the same angle. Illustrations that form part of the design should, whenever possible, be on separate cylinders from the type matter: ink viscosity can then be adjusted lower for illustrations, higher for type.

Care must be taken to avoid pulling uncoated foil webs over stationary bars, or any other surface likely to provide friction, because of the risk of permanently marking the surface of the metal.

Inks used in gravure printing on foil must be fast drying and the solvent lineup should be such that solvents are entirely removed by volatilizing. Type C inks are formulated with the fast drying solvents necessary for foil work, and type E inks are particularly suited where residual odor is a factor.

It should be remembered that for labeling applications where labels are removed by caustic solutions, caustic soluble inks should be employed. In all cases consult your ink supplier: although printing inks for foil will sometimes work very well on paper, paper inks will seldom perform satisfactorily on foil.

Flexography

Flexography is a rotary letterpress operation in which rubber plates are used to print a moving web of stock with inks which dry instantly by evaporation. The main reasons for the popularity of this process are the simplicity and economy of press design and construction as well as the ability to setup and preregister the job off the press, thereby minimizing down time and making short press runs economical.

This process is best suited to printing designs with line detail only and is restricted in the application of these designs on foil only by limitations of the rubber plates for reproducing fine lines and halftones. Anything finer than an 85-line screen usually requires excessive attention to prevent filling in of the pattern.

Flexographic inks for foil printing are alcohol base and dry completely by evaporation, thus enabling the same wash coated or treated foil surface to be used as in gravure. The same precautions of running web stock apply as do to gravure, and here again the criteria of run size and quality of printing detail are determining factors.

Lithography

The principle of lithography is based on the simple fact that oil and water do not mix. The printing areas of images are sensitized on the metal plate so as to accept ink, and the areas not to be printed are moistened with water so as to repel inks.

Lithography has long been absent from the field of foil printing; however, there is a large market which can be served by this method of reproduction. Recently, a great deal of interest has been shown in foil lithography and many lithographers throughout the country are accepting and profitably printing commercial jobs on foil.

There are several reasons why lithography on foil is desirable. First, standard litho presses are used, and lithography is by nature practical and economical on small or moderate runs. Secondly, litho on foil is capable of excellent reproduction, to the extent of photographs in full color if necessary. Thirdly, plate costs are moderate and unrelated jobs can be grouped on the same plate. Also, sheet sizes of up to 52 by 76 in. are possible, something outside the scope of gravure and flexography.

Lithography on foil may be accomplished on any weight of laminated stock from 30-lb. paper-backed to heavy weight board stocks. Generally, 60 lb. and up is preferred for sheet fed equipment, whereas web fed can use 30 lb. and up.

It is generally agreed that the use of a nitrocellulose or vinyl-type coating is most satisfactory for lithographic reproduction. This type of coating assists in drying of the oil-type inks, and, where areas of unprinted foil are exposed in the finished job, there is less tendency to finger mark. Where ink coverage is complete some lithographers have worked satisfactorily on a treated or wash coated foil surface. It is always best to supply a sample of foil stock to the ink manufacturer so that ink adhesion can be checked in advance.

The direction of grain in the paper is not too important, especially in the heavier weights. In using lighter weight stocks it is more desirable to cut the sheets so that the wrap around the rollers conforms to the natural curl tendency of the paper. As in lithographing on paper, the foil sheets should be laid and stored only on flat surfaces.

On standard litho presses, there is no drying equipment and dry offset sprays with special foil inks have been used on most of the commercial jobs to date. There is, however, still some

work to be done on the aspect of auxiliary drying in order to insure large volume work at top machine speeds.

It has been found that there is a tendency for the first station of multiple color presses to leave a slight film of moisture on the unprinted foil surface. The foil, being nonabsorbent, retains this moisture and the second color is applied on the damp surface. This can result in nondrying of ink or lack of adhesion. The use of auxiliary drying equipment is being explored to solve this problem.

To prevent the accumulation of water in the ink fountain and on the rollers, which could cause drying and adhesion problems, periodic press cleaning is desirable.

It is advantageous that the litho plates carry as little water as possible. The first attempts used deep-etch zinc plates made exactly as for printing paper. They gave excellent results and to a great extent are still being used. However, copperized aluminum plates were found to be an improvement. The copper areas, having a high affinity for grease, are used for printing; the nonprinting areas are fine grained aluminum. Lithure plates are still another improvement. They are made by depositing copper over aluminum and then depositing chromium over the copper. Printing areas are created by etching so as to have a printing area of copper and a nonprinting area of chromium. Albumin plates are not recommended for foil work.

Screen sizes of 133 to 150 are not uncommon in foil work in that foil has no limitations as to the screen fineness that may be employed.

In areas to be printed white it is sometimes necessary to apply two passes of color to obtain the desired opacity. In white areas that are to be overprinted it is common practice to allow the white ink to dry overnight. However, recent ink developments may render both of these steps unnecessary in the near future.

One of the principal deterrents to lithographing on foil has been the offsetting of inks onto adjacent paper surfaces during stacking. However, during the past few years a great deal of development work has been done on this, particularly by I.P.I. and Pope and Gray, with regard to improvement of the drying and setting rates of inks.

Sheets delivered from a litho press are stacked with the help of lifts. Sheets have been stacked from 500 to 2000 high depending upon the weight of the stock, the type of ink used, the size of the printed area, the thickness of ink film, and the surface finish of the back of the sheet.

Letterpress

Although letterpress is the oldest form of mechanical printing, it still remains widely used in the packaging field. Its most prominent advantages are strong solids, brilliant colors, relatively easy color control and sharp, clear-cut details. Also, letterpress is probably the most flexible process where changes and corrections are involved.

Letterpress is somewhat limited because of the slow drying characteristics of the inks, a definite detriment to foil printing, and plate wear on long runs. Recently, gloss heat-set inks have been successfully developed for printing on web fed presses, and combinations of heat-set and the usual oil-base inks and other so-called quick-set inks have resulted in faster-drying inks, helping to get the printed job through the manufacturing process more rapidly.

One of the most striking jobs to be produced on high-speed rotary letterpress equipment (Cottrell press) was the recent Reynolds *Better Homes and Gardens* ad. This ad was printed at a rate of 850 f.p.m. (15,000 impressions per hr.). The drying ovens maintained temperatures of 500 to 600°F., and the process included special flying pasters for splicing and a special foil coating to withstand the heat.

Generally, there are but a few points to be given special consideration in letterpress printing of foil. For best results it is recommended that a cylinder packing of oiled manila tympan sheets or press board be used with only enough superhangers to take care of the make-ready operation. Some printers find that placing a sheet of celluloid directly under the top sheet, scoring it and tucking it under the cylinder clamps, will give the necessary resilience and firmness required for sharp clean impressions. A kiss impression prevents unnecessary embossing of foil stocks.

The use of emery cloth strips on the top sheet directly under the grippers will help to secure perfect register. Rollers should be fairly snug on the plate. The number one roller should have enough tack to keep the form clean; this also helps to make the ink lay smoothly.

It is generally advisable when printing from electros to use a patent base rather than wood blocks because of the additional firmness under pressure.

Whenever possible, use inks full strength so that a very light or thin film will give the desired color with the least tendency to offset. As in lithography, sheets of printed stock should be racked for drying and the same practices of stacking should apply.

Silk Screen

Silk screen printing offers many advantages to the packager, but of prime importance to foil printing is the ability to make runs for test purposes, for problem jobs, or for specialty applications. Some cosmetic manufacturers use silk screen for box wraps printed on foil. A recent rather interesting use of silk screen work was in a test marketing of Rit dyes wherein small quantities of various colors were needed as an addition to the basic foil label.

Silk screen has not reached the proportions on foil work that it has in some fields; however, its versatility for point-of-purchase merchandising aids is unexcelled. Several recent developments in silk screen printing have aided its adaptability to foil, notably rapid-drying inks and drying equipment to improve production speeds.

The newest methods for making screens reproduce finer detail and smaller type; however, half tones still must be kept below 85 line. For finer jobs, combinations using letterpress or lithography are used.

CONCLUSION

Satisfactory printing on foil by any of these processes just mentioned is dependent upon a number of very important factors, such as the consideration of the right type of stock, the right foil surface and inks, and proper equipment. Your foil laminator and ink suppliers are always available to assist in whatever problems you may incur and appreciate the opportunity to assit you whenever they can. One point to remember in the actual printing: you are not printing on aluminum foil but rather on an ink-receptive coating on the foil.

Presented at the meeting of the Lake Erie Section of TAPPI held in Cleveland, Ohio, Dec. 18, 1958.

Pacific

The Pacific Section of TAPPI held its second meeting at the Hotel Monticello, Longview, Wash., Nov. 18, 1958. The general subject was Papermaking, and was ably moderated by Jack Weiblen of the Columbia River Paper Co., Vancouver, Wash. The program began promptly at 2:00 p.m. with the following papers being presented:

1. "White Water Clarification" by Jack Decker, Columbia River Paper Mills.
2. "Application of Enzyme Converted Starches" by Delos D. Wilma, Longview Fibre Co., Longview, Wash.
3. "Surface Treatment of Paper and Paperboard with Starch and Pigment" by John T. Bainbridge, Penick and Ford, Ltd.

From the lengthy question-and-answer period following each of the papers and the conclusion of the technical session

it was apparent that a very interesting program and presentation had been made.

Dinner, preceded by a social hour, followed the technical session. Bruce Johnson, Rayonier, Inc., Seattle, Wash., spoke to an interested audience numbering almost 200 people on "Washington State Finances and You."

ROBERT SMYTHE, *Secretary-Treasurer*

Indiana District

The Dec. 16, 1958 meeting of the Indiana District of the Ohio Section of TAPPI was held at the Marott Hotel, In-

Indiana District of the Ohio Section (TAPPI). Left to right: John S. Sullivan, Monsanto Chemical Co.; Charles E. Eberly, Paper Art Co.; Wally Walters, Beveridge Paper Co.; Harris O. Ware, Beveridge Paper Co.; C. B. Hallobough, independent patent attorney, New York; W. D. Boggess, Beveridge Paper Co.; and Cushing Roth, Morningstar-Paisley Co.

dianapolis, Ind. There were 40 members and guests present. Guest speakers included Wally Walters of Beveridge Paper Co., Indianapolis, Ind., who spoke on "Nonfibrous Raw Materials" with excellent visual aids. C. B. Hallobough, LLB. of New York gave a most interesting talk on patent law. The February meeting will be held in Hartford City, Ind., and will include a tour of the 3-M plant and dinner following at the Moose Club. Brage Golding of Lilly Varnish Co., Indianapolis, Ind. will speak on "Functional Coatings." Several other out-of-town tours and meetings are planned for the coming months.

Southeastern

Florence, S. C., was the location of the Southeastern Section of TAPPI meeting which was held Nov. 14–15, 1958. Sonoco Products Co. was host for this meeting.

The dinner meeting was held Friday night, November 14, at the Florence Country Club in Florence, S. C. Registration began at 5:00 p.m. The social hour began at 6:00 p.m. followed by dinner at 6:45 p.m. The business session and technical program followed the meal.

The high light of the business session was the announcement of the awards contest winners for the 1957–58 season. The technical program consisted of three papers ranging in subject matter from the basic principle of kraft pulping to the use of glass fibers in papermaking. The feature paper of the evening, entitled "The Clupak Story," was presented by Charles A. Shoudy. The following papers were presented:

The first paper of the evening was presented by Leslie L. Warner of Owens-Corning Fiberglas Corp. Mr. Warner dis-

C. W. Coker, Sonoco Products Co., presenting the welcoming address

cussed "Glass Fiber Contribution to the Dimensional Stability of Paper."

Everett D. Cann, research chemist with the Hudson Pulp and Paper Corp. presented the second paper of the evening, entitled "The Basic Principles of Kraft Pulp Production." Mr. Cann discussed the general characteristics and variables of the kraft pulping reaction to show how they can be utilized to develop the required pulp qualities under mill conditions.

The feature paper of the evening was presented by Charles A. Shoudy, assistant manager in charge of production, West Virginia Pulp and Paper Co. Mr. Shoudy presented a paper entitled "The Clupak Story." The story started with a brief history of how West Virginia Pulp and Paper Co. and Cluett-Peabody and Co., Inc., evolved a working agreement to jointly develop a stretchable paper. Some of the effort that went into turning the idea of the inventor, Mr. Sanford L. Cluett, into a working reality on a high speed, 264-in. wide kraft paper machine were told. The theory behind the process used in making Clupak paper was explained and some of the characteristics of Clupak paper was compared to regular paper. In addition, Mr. Shoudy presented the concept of toughness and how it relates to bag performance.

On Saturday morning, November 15, the members visited Sonoco Products Co., in Hartsville, S. C.

Winner of first place in the 1957–58 Southeastern TAPPI Awards Contest for papers presented during the year was Jimmie H. Smith of Southern Paperboard Corp. His paper was entitled "Ring Crush Test." The second place award went to John M. Mallary of Union Bag-Camp Paper Corp. for his paper entitled "Modernization of a Paper Machine Condensate System." There were seven papers entered and the judges reported a very close contest. The first place winner

R. A. Flick presenting the first award to J. H. Smith of Southern Paperboard

R. R. Chase presenting the second place award to J. M. Mallory, Union Bag-Camp Paper Corp.

was awarded a prize of $100 while the second place award carried a $50 prize. Both were awarded plaques. Another contest is to be sponsored again this year.

J. B. Doughty, *Recording Secretary*

The Clupak Paper Story

C. A. Shoudy

The task of evaluating the commercial possibilities of a laboratory process for making stretchable paper, invented by Sanford L. Cluett, vice-president of Cluett, Peabody and Co., Inc., and then adapting the process to modern paper manufacture was initiated by West Virginia Pulp and Paper Co. in mid-1954 and continued for the best part of three years.

The project began with a visit to Mr. Cluett's laboratory and the Cluett, Peabody plant in Troy, N. Y., and concluded with the first successful commercial run of extensible paper at the Charleston, S. C., mill of West Virginia on Dec. 26, 1957.

Mr. Cluett's laboratory model put stretch in 2-in. strips of paper by a simple mechanical process using heated steel rolls and a rubber blanket, which compacted the fibers of a wet sheet. In the Cluett, Peabody plant, we saw that there was some similarity between this method and the compressive shrinkage process for textiles, also an invention of Mr. Cluett. The latter process is mechanical, too, but when the fabric is compressed it does not stretch.

The project of developing the process for manufacturing extensible paper was given directly to the company's Charleston mill organization. A team of product development, technical, and engineering personnel was assigned to the job. Their first task was to study the fundamentals of the process, which was done with Mr. Cluett's 2-in. wide laboratory model.

During this period, some experimental work was carried out on Charleston's no. 2 machine by modifying the breaker stack, but the results were inconclusive.

Based on the results of our initial studies, it was then decided to design and build a pilot compressor unit 60 in. wide, based on roll diameters which were believed necessary for a large machine installation. The unit consisted of a chrome-plated drier and a rubber blanket, as shown in Fig. 1.

If you will refer to Fig. 2, you will see why this equipment imparts machine direction stretch to paper.

As you know, rubber flows when it is compressed or stretched. The rubber blanket is supported on a nip roll which compresses the blanket against the drum. Sections 1, 2, 3, and 4 all have the same area. Section 1 shows the blanket in its normal state. Section 2 shows the dimensional change as the blanket passes over a roll. The outer ply of the

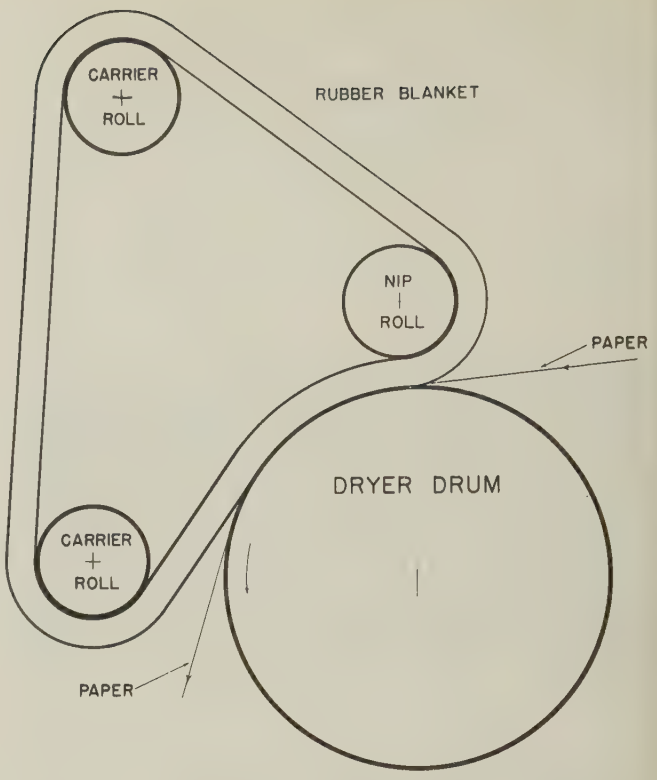

Fig. 1

blanket is expanded slightly whereas the inner ply against the nip roll contracts slightly. As the blanket passes through the restricted nip area, both outer and inner plies are expanded considerably, as shown by section 3. We are interested in the action of what used to be the outer ply of the blanket since this is where the paper enters the nip area. As you can see, the paper is placed against a stretched rubber blanket. By the time the paper and blanket have reached the point shown by Section 4, the blanket has returned to its normal state and even contracted slightly due to the change of blanket direction. If the paper is held by the blanket and slips on the drum, the paper must also be compressed from its original state. This is the theory behind the patent. It is so simple one generally wonders why he didn't think of it.

The 60-in. pilot unit was placed in operation Aug. 31, 1955, more than a year after our original meeting with Mr. Cluett. Paper for this unit required a high degree of moisture content, which we were able to provide from our no. 2 machine. Rolls 48 in. wide were cut on the winder, wrapped in polyethylene, and trucked to the pilot unit.

On Nov. 8, 1955, the first acceptable stretchable paper was made on the pilot unit. The paper was dried by rerunning it

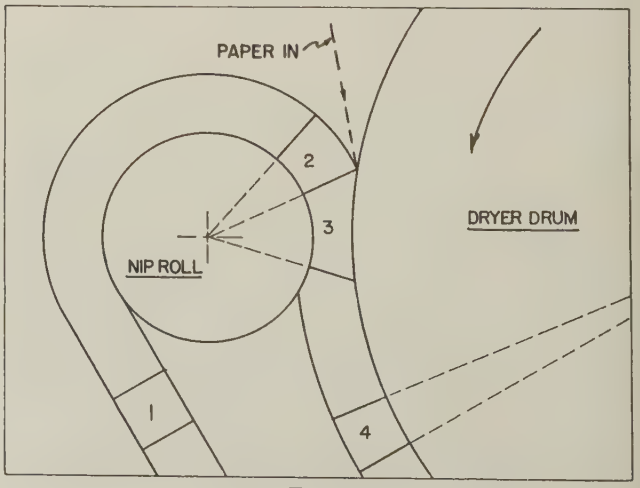

Fig. 2

C. A. Shoudy, West Virginia Pulp and Paper Co., Charleston, S. C.

through the unit several times with the blanket nip backed off, since no other driers were available.

We had made enough progress by this time to move into product testing and on Dec. 13, 1955, the first multiwall bags made of stretchable kraft paper were made at a southern bag plant where we had rented time on the bag making equipment. The appearance and performance of the bags were very encouraging and we decided to initiate field tests.

To speed up the output of paper on the pilot unit, a set of driers was installed in late 1956. As a result, production through the unit was continuous, control improved, and we were able to make a much better sheet of paper.

Encouraged by reports from field tests and convinced that we were able to make a really superior paper, the management decided in January, 1957, to install an extensible unit on a kraft machine at the Charleston mill.

Beloit Iron Works was given the job of making the equipment and several months elapsed in order to obtain the design data needed to allow the prototype conmercial unit to be built. By the middle of April, 1957, it was decided to install the unit on the new no. 3 machine, which was under construction.

Number 3 machine, 264 in. wide, was started up on Aug. 15, 1957, to make lightweight conventional kraft paper as originally planned. The machine then was shut down about four months later to install the unit for making stretchable paper. The job was started on December 9, and 9 days later the machine was turned over to the papermakers with the extensible unit ready for operation.

We manufactured a product considered almost acceptable just prior to the Christmas shutdown, which started the morning of December 24 and extended for two days.

At 8:00 a.m. on December 26, we went back to work. At 10:20 that night, the first extensible paper was made.

As you know, whenever a paper machine is started up after being down, or when an order change is made, the first thing the back tender does when paper is brought over the machine is to take a sample and cut it to size to check the basis weight. When the first Clupak paper came over no. 3 machine, one of the foremen went in to take the sample. He took hold of the sheet and tried to tear it, first with one hand, then with two. Eventually he had to call for a knife in order to get a piece of this sheet. Those of us who saw this knew we had extensible paper even before we saw the test laboratory results.

The laboratory results indicated that we had gone from a normal machine direction stretch of about $1^1/_2$ to 2%, to a sheet with about 13% stretch.

Before discussing the characteristics of Clupak paper, let's review the properties of conventional paper. Paper, as you

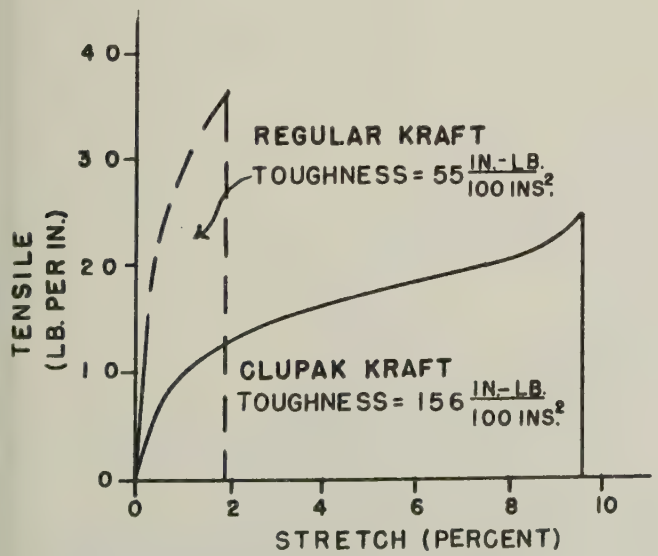

Fig. 3. Machine direction—50 basis weight

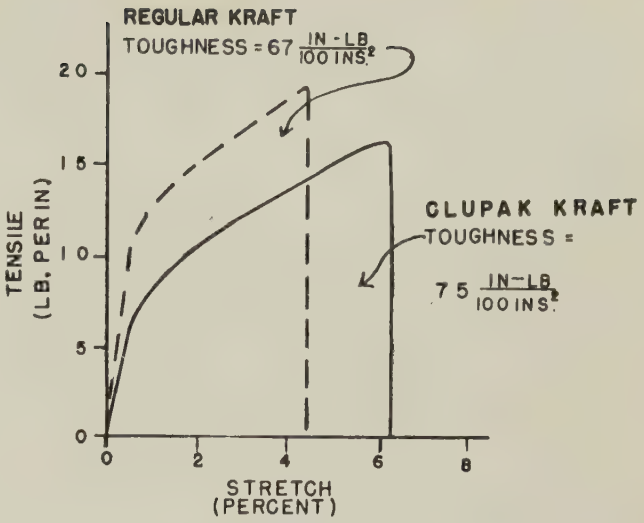

Fig. 4. Cross machine direction—50 basis weight

know, is not uniform. The paper the industry is making today is far superior to the product we made 20 years ago, 10 years ago, or even 5 years ago. But it's still not completely uniform. For one thing, paper is two-directional. The fibers tend to line up in one direction as they flow down the wire. We know that conventional paper has very little stretch in the machine direction. In the cross machine direction, however, paper has a fair amount of stretch, although the amount is not uniform. Paper on the edges of a machine has more cross-directional stretch than paper made at the center of the machine. Paper will tear more easily in the machine direction, where the fibers are more or less lined up, than it does in the cross direction when you tear across the fibers.

Now let's compare Clupak paper and regular paper. The formation of the fibers at the wet end of the machine is the same for Clupak paper as it is for conventional paper because that end of the machine has not been changed by the extensible process. So, if a paper has certain basis weight variations, it will be roughly the same whether it is Clupak paper or conventional paper. The same goes for sizing, pH, or any factors controlled on the wet end of the paper machine.

As to some of the other physical properties of the paper, we have increased the machine direction stretch of our paper about 500%. At the same time, the machine direction tensile has been decreased by about 25%. For the cross direction, we have slightly increased the cross machine stretch and the cross direction tensile is practically the same. The density (resistance to air penetration) has definitely been increased on Clupak paper beyond that of regular paper. In addition, Clupak paper is not so stiff as regular paper.

I'd like to talk to you a while about the concept of toughness in determining the strength of paper. Whereas we find that our European neighbors have been using this important concept for some time, we in this country, unfortunately, have not.

Remember your old high school physics definition of "work?" Work is equal to force times distance. In the case of paper, tensile is equal to the force, and stretch is equal to the distance. The area under the stress-strain curve of paper, as it is pulled until it breaks, is the work it takes to break the paper. This we call toughness. Now let's look at Fig. 3 which shows the toughness curve of a normal 50-lb. multiwall sack sheet compared to a 50-lb. Clupak paper sheet. Notice how the regular paper resists pull but breaks before it stretches 2%. The area under its curve (toughness) is 55 in.-lb. per 100 sq. in.

The Clupak paper sample does not have so much tensile strength as the regular paper, but it resists the pull much longer and stretches a great deal more before it ruptures. As a result, the area under its curve, or its toughness, is 156 in.-lb.

per 100 sq. in. This particular comparison shows that Clupak paper is three times tougher than the regular paper in the machine direction.

Figure 4 shows similar curves for regular 50-lb. multiwall sack paper and 50-lb. Clupak paper when stretched in the cross machine direction.

Europeans have been using this toughness concept in determining their bag construction whereas we, in the United States, have been using a specification called UU-S-48b, now corrected to UU-S-48c, which when analyzed in the light of today's scientific knowledge has little correlation with bag performance. Previously these specifications were practical since we were unable to measure stretch accurately. Now that the industry has instruments that can do an accurate job of measuring stretch, tensile, and work, however, new specifications which correlate with bag performance are needed. We believe that the unit for these specifications should be toughness, and that's what is being solid in Clupak paper.

Presented at the meeting of the Southeastern Section of TAPPI held in Florence, S. C., Nov. 14, 1958.

Glass Fibers Contribution to Dimensional Stability

Leslie L. Warner

Glass is probably one of the more unusual fibers to be used in paper, but glass is a paper fiber because it gives unique properties to paper. Glass is a man-made fiber, it is inert to most outside influences, it will not rot, it is verminproof, it won't burn, and it doesn't absorb moisture. Glass is made basically from sand. The sand is melted down and the glass formed into marbles about $^3/_4$ of an inch in diameter and from each marble we draw 96 miles of 9-mu glass filament.

Figure 1 is a schematic drawing of how we form glass fibers. Glass marbles are fed to a re-melt tank, or what is called a bushing. This bushing is made of platinum, that being one of the few materials that glass does not dissolve. In the bottom of each bushing are 204 tiny holes through which the molten glass is drawn to form the filaments or glass fibers. The glass filaments are drawn together at the size applicator. The size applicator applies a material which binds the 204 filaments together into what we call a strand. This size material is necessary to hold the material together while it is being processed. Now this size material serves other purposes. For textile uses, a size is applied which acts as a lubricant when the strand is passed through guides or over pulleys and the multitude of devices used in forming textiles. Glass fibers for the papermaking industry require a size which holds the fibers together until they are chopped. Whereupon this size must allow the strand to disperse into the individual filaments. Once the fibers are in the paper the size should result in a glass-to-glass or a glass-to-cellulose bond in a finished paper. In this manner, we can take some advantage of the tremendous strength of the glass filaments, thereby increasing the tear and tensile strength of the paper. From the size applicator the strand is passed to the winding tube and here the strand is wound up into a package to go to the next operation.

The forming packages are re-wound into a 60 end roving ball to be shipped to the point of use or are sent to our cutter department. Here 60 end roving is chopped into $^1/_4$-in. lengths for paper manufacturing. A cutter can be mounted over a stock chest consistency adjustment tank, or other convenient point in a pulp handling system. In this type of operation glass fibers from a 60 end roving package would be chopped directly into pulp and the cutter would be acting as both a chopper and metering device. The first thing noticed as glass is introduced into a paper machine is the receding of the "sheen" toward the headbox. Glass fibers increase the drainage rate of most pulps, and this has been proven (1) by observing this movement of the sheen toward the headbox, (2) by drainage

Leslie L. Warner, Owens-Corning Fiberglas Corp., Ashton, R. I.

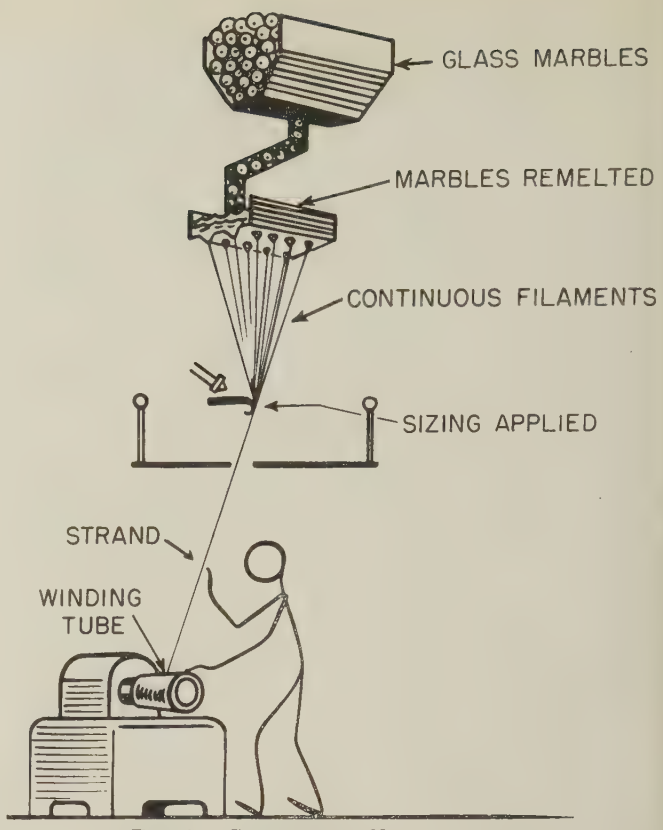

Fig. 1. Continuous filament yarns

measurement under a machine wire, and (3) by Canadian and Williams freeness checks. The glass fibers also increase the drying rate. The second place where a visual change occurs is in the drying section where a draw adjustment may be necessary. The glass sheet does not shrink, therefore, a looping sometimes occurs in the dry cans. A third point where a visual evidence of glass in the paper furnish becomes apparent is at the dry end or reel. Here you will notice a widening of the

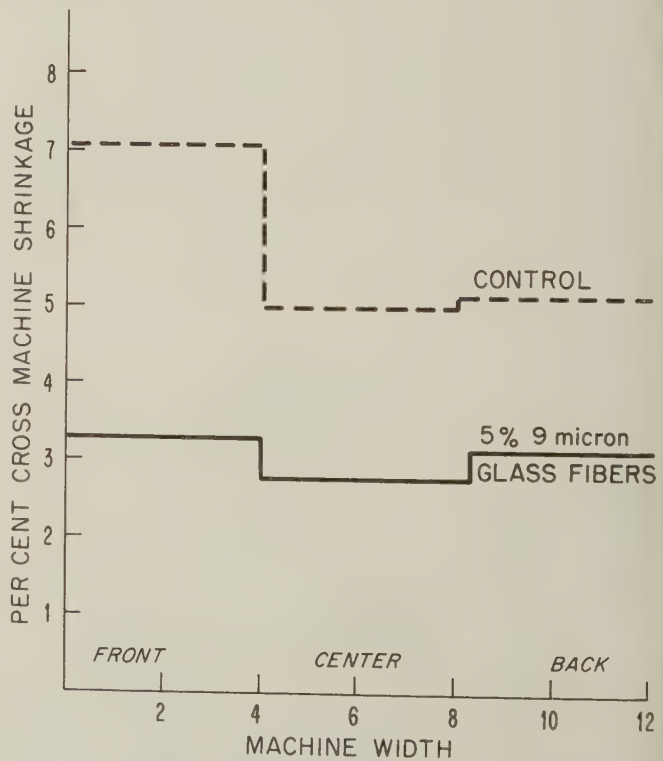

Fig. 2. Machine shrinkage study. 54 Pound (25 × 40–500) sheet; 60% bleached pine sulphate, 40% bleached poplar sulphite

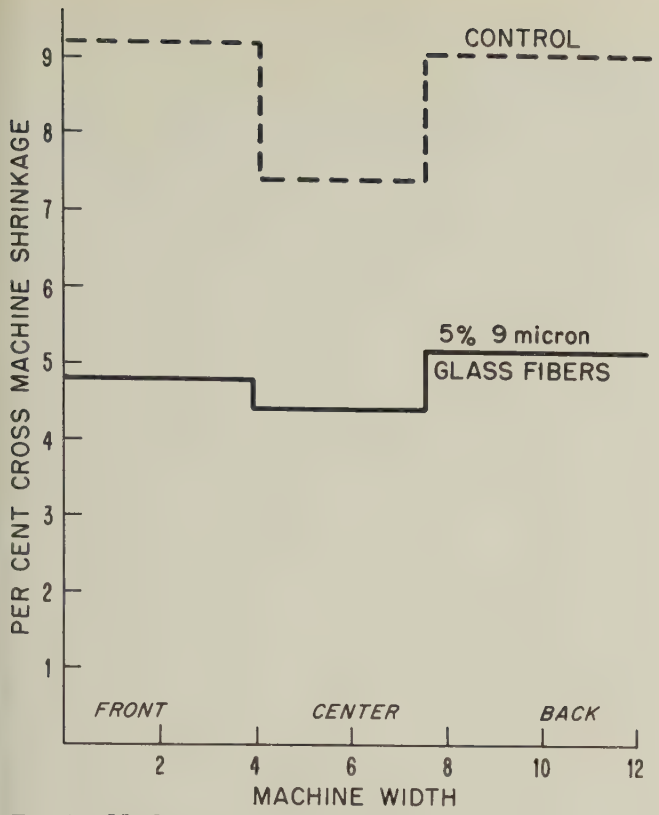

Fig. 3. Machine shrinkage study. 70 Pound (25 × 40–500) sheet; bleached pine sulphate

sheet. This will be in the range of 2 in. on a 100-in. machine.

These are the general and basic effects of adding glass fibers to pulp hereinafter we will consider the effect of glass fibers on the finished paper web.

Dimensional stability is increased markedly by the incorporation of glass fibers in the paper web. The increase in dimensional stability is great for even a small percentage addition of glass fiber. The exact mechanism of this increased stability is not certain but some theoretical basis for the observed results is given in two papers published in the January 1958, issue of *Tappi*.

Lars. S. Nordman of the Finish Pulp and Paper Research Institute in a paper which was printed in the January, 1958,

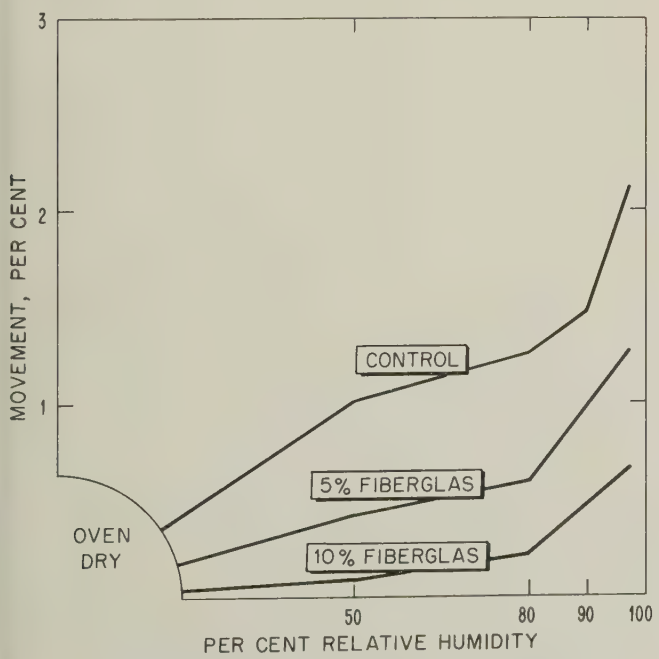

Fig. 4. Dimensional movement. Hardwood sulphate pulp

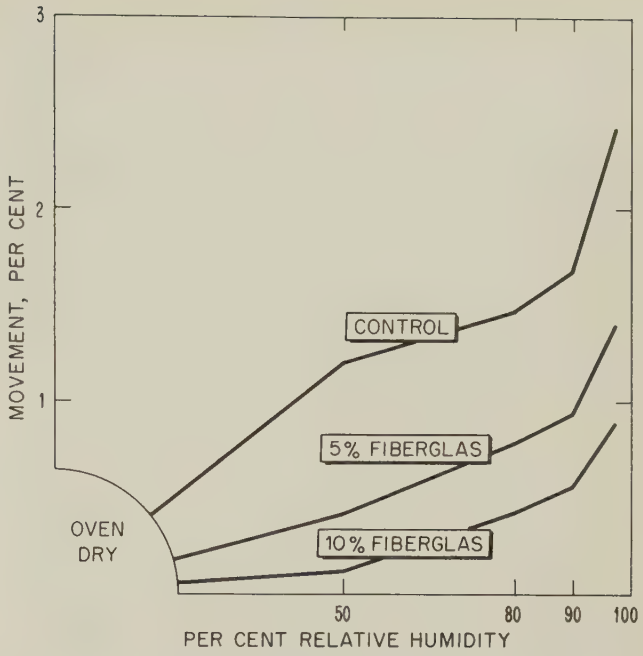

Fig. 5. Dimensional movement. Hardwood neutral sulphite semichemical pulp

issue of *Tappi* stated that a linear relationship exists between machine shrinkage and moisture expansivity not changed by altering pulp quality, type of beating, or additions of certain chemicals to the pulp.

H. O. George of International Business Machines Inc. has reported that if the shrinkage in width can be restricted by using a free-stock, by external mechanical means, or by internal mechanical means the net result is improved stability. Upon adding glass fibers to paper, that is exactly what is accomplished. First, the stock is made more free, as evidenced by the increased drainage rate. Secondly machine shrinkage is reduced. Therefore through the incorporation of small amounts of glass fibers (2 to 10% on dry sheet weight basis) the dimensional stability of paper should be improved.

At the Forest Products Laboratory, September, 1958, during a pilot machine run a measurement of machine shrinkage was made (Fig. 2). Here over-all cross machine shrinkage was reduced 53% on a 54-lb. offset paper and Fig. 3 indicates a

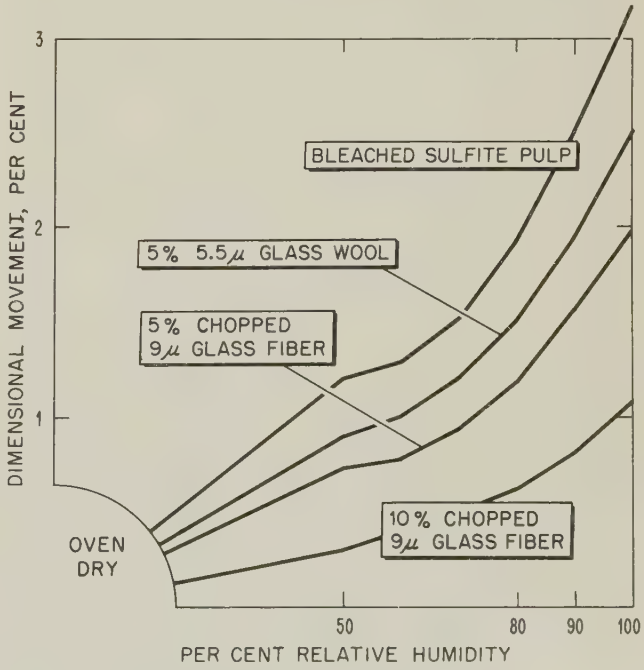

Fig. 6. Dimensional movement

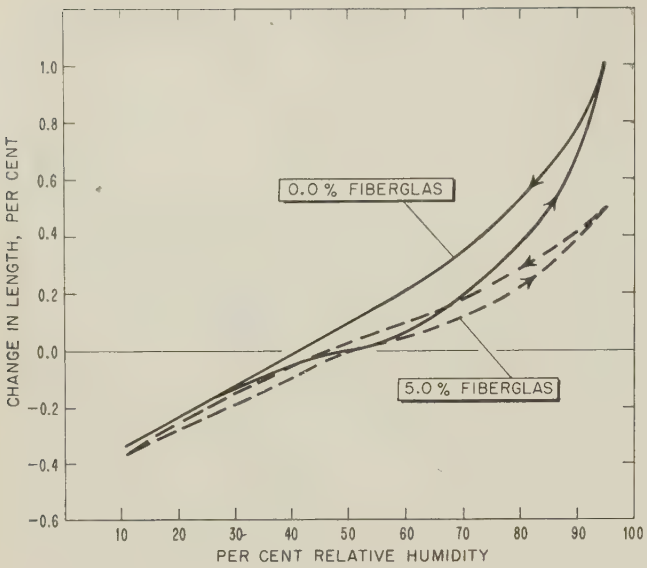

Fig. 7. Hygroexpansivity hysteresis curves across machine

similar 53% reduction in over-all cross machine shrinkage on a 70-lb. plate stock. The cross machine shrinkage study shows that web shrinkage is more uniform across the machine with glass fiber in the stock. This would result in better dimensional stability from a greater percentage of the web than the sheet without glass.

Figure 4 is a dimensional stability study showing the effect of glass fiber in a hardwood sulphate pulp. The sheets were first oven dried, slits were made in the sheet 11 in. apart, the sheets were then subjected to controlled humidity until equilibrium was reached when new measurements were taken. The control sheet hygroexpansivity at 50% R.H. was approximately 1%. At 98% R.H., the expansion was well over 2%. Upon the addition of 5% Fiberglas, the hygroexpansivity was reduced approximately 50% and upon the addition of 10% chopped glass fibers the expansivity was reduced to less than $^1/_4$ that of the original.

Figure 5 depicts the effect of glass fibers in a hardwood neutral sulphite semichemical pulp. The control at 50% R.H. had expanded 1.2%, at 98% R.H. it had expanded well over 2%. Again 5% glass fibers reduced the expansion more than 50 and 10% additions of glass fibers, reduced it to less than a third that of the original.

We have also experimented with different glass fibers. For example, a glass wool material has been used in papermaking.

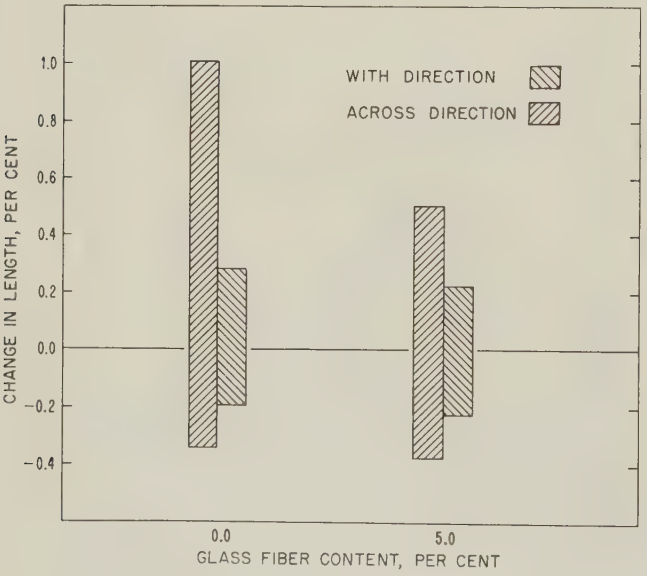

Fig. 8. Hygroexpansivity of papers containing Fiberglas

Figure 6 shows the comparative value of glass wool and chopped glass strand in achieving dimensional stability in paper. The 5% 5.5-mu glass wool did not increase dimensional stability as much as 5% chopped 9-mu glass fibers.

In this study of dimensional stability we have also made hygroexpansivity curves. Figure 7 is one such curve. The solid line denotes a western hemlock sulphate pulp which started out at 50% R.H., increased in stages to 94% relative humidity then decreased to 20% R.H. and back to the original 50% R.H. A similar test was made on a sheet containing 5% chopper Fiberglas. Here are the results of this study. The total dimensional movement was about $^2/_3$ that experienced in the control and the hysteresis loss is less than $^1/_3$ that of the control sheet.

Figure 8 shows the same paper in the same hygroexpansivity study in the form of a bar graph, portraying movement in both the cross machine and machine direction. This slide points out dramatically that our sheet is very nearly a square sheet in greatly improved dimensional stability.

Glass fibers are being used at the present time in a newspaper matrix paper where dimensional stability is a factor especially in color reproductions. It is being used in air filters where controlled porosity is a factor. It is being used in resin impregnated board, saturating papers, and in decorative papers. The glass fibers are added to the paper machine after the final refining process. They can be added at the stock chest, at the fan pump, the white water return system or they can be passed through a jordan if the plug is backed off. The fibers can be chopped directly into your system and the chopper used to meter the glass into the pulp. The glass fibers will pass through a Dirtex, or a Bird screen if the slots are 14 thousandths of an inch wide or better. The glass fibers are added any place there is good agitation and where there is some time for them to disperse before they hit the wire. Extensive modification of existing equipment is unnecessary, and the only machine problems are those caused by increased drainage rate, reduced machine shrinkage, and increased drying rate; all requiring only minor machine adjustments.

In summary, I believe glass fibers are papermaking fibers for these reasons:

1. Glass fibers increase pulp drainage rates.
2. Glass fibers increase web wet strength.
3. Glass fibers increase drying rate.
4. Glass fibers reduce machine shrinkage.
5. Glass fibers reduce hygroexpansivity of paper resulting in greater dimensional stability.
6. Glass fibers can provide controlled porosity in paper.
7. Glass fibers increase tear resistance.
8. Density can be reduced or bulk increased by the use of glass fibers in papermaking.

Presented at the meeting of the Southeastern Section of TAPPI held in Florence, S. C., Nov. 14, 1958.

Gulf Coast District

The Gulf Coast District of TAPPI met at Martines Restaurant in Pensacola, Fla., on Nov. 21, 1958.

Chairman J. E. Doyle of St. Regis Paper Co. presided at the meeting. Mr. Doyle announced that the Local Sections Operations Committee and the Executive Committee of National TAPPI had voted to grant a section charter to the Gulf Coast District of the Southeastern Section of TAPPI, and that the charter would be presented at the May 15, 1959, meeting in New Orleans.

Mr. Doyle introduced R. G. Macdonald, executive secretary of National TAPPI. Dr. Macdonald congratulated the officers and members of the district for their fine work leading up to the granting of section status.

Mr. Doyle also introduced John Weidner, technical director of Container Corporation of America, Brewton, Ala. Mr. Weidner welcomed the members and invited them to visit the Brewton mill on Saturday, Nov. 22, 1958.

Following the business meeting, Program Chairman M. T. Still presented the speakers for the evening. The papers presented were as follows: "Hardwood Barking," by Thomas N. Baker, St. Regis Paper Co., "Control and Treatment of Pulp And Paper Mill Waste," by Vincent D. Patton, Florida State Board of Health; and "Biological Aspect of Streams," by Robert F. Balch, The Institute of Paper Chemistry.

Prior to the evening meeting the Executive Committee met with Dr. Macdonald to discuss plans for future meetings and other business.

A. L. Hargraves, *Recording Secretary*

Empire State (Eastern District)

The October meeting of TAPPI was held in Menands, N. Y. Jim Stiles, personnel manager and industrial relations manager of Williams Press was guest speaker for this evening. His topic "Operations at Williams Press" gave the history of the growth and modernization at Williams Press. Considerable discussion ensued on industrial relation problems which Mr. Stiles was able to give much enlightenment.

A tour of Williams Press preceded the evening meeting. Forty-one members toured the plant and 61 attended the meeting.

The November meeting was held at the Queensbury Hotel, Glens Falls, N. Y.

The meeting was opened and a report from the various committee chairmen was given:

Dick Boss solicited support for his junior awards contest. Announcement would be in the mail soon.

Bill Lord, head of membership committee, encouraged the membership of guests.

Roger Traxler announced he was under way on the educational program and would have notices out by December 1. A follow-up would be made after the Christmas holiday. Last year 105 essays were submitted.

Clyde Davis reported a balance of $215.11 in the treasury.

Gordon Nickolson reported a correction on the program cards. The instrument session was scheduled for December 18 meeting.

The speaker for the evening was Howard E. Kuehn whose talk was on roll crowns. Mr. Kuehn is division engineer for Farrel-Birmingham Company, Inc., well known in the paper industry for calender rolls. His presentation was very interesting and informative.

Alex Pociluyko, *Secretary*

Empire State (Central District)

The December 5 meeting of the Central District of the Empire State Section was held at the University Club in Syracuse, N. Y. The subject for the evening was a "Panel on Sizing." Guest speakers were Hugh Holland of the Monsanto Chemical Co.; John Cochran, Hercules Powder Co., and C. G. Landes of American Cyanamid Co.

The following is an abstract of the talk given by Mr. Holland, Senior Sales Engineer of Monsanto Chemical Co.

Fortified size is 15 years old and nearly 100% of the mills have adopted its use. Original rosin size was made from wood and gum plus alkali. This makes a water-soluble product which is diluted for addition to the furnish. Today, three sources are used: gum, wood, and tall oil. Tall oil is obtained from kraft production.

The chemical differences are increased activity due added acid groups. Physical differences are the addition of more particles of size per pound. This product was theoretically developed by one of our research directors who was a physical chemist.

The main reason for adoption of fortified size is the dollar savings. Naturally, the best introduction of a new concept is to save management money and operating personnel headaches. This fortified size has done. Quite possibly adoption would have come about without savings for there is more to this product than mere money savings. It gives a harder sizing than rosin, i.e., special grades, purer brighter pulp. Additional benefits are using less size for the same sizing. Sizing is good for water resistance, but detrimental to most other paper qualities, for example, bursting strength. Brightness losses from 2 to 4 points are observed from size. This is especially important in trying to achieve incremental brightness in the highest ranges. Brightness loss is reduced by using less size. Fortified size gives improved uniformity of sizing, since it is resistant to furnish changes and papermaking variables.

The above talk was illustrated with several slides.

Notes on Aquapel® sizing was the topic of Mr. Cochran's of the Hercules Powder Co. talk.

[*Editor's Note:* Because of previous publication in this journal (Davis, Roberson, and Weisgerger, "A New Sizing Agent for Paper—Alkylketene Dimers," Vol. 39, pages 21–23, January, 1956) some of the author's introductory explanations, including the chemistry of ketene dimers and theories of sizing, have been omitted.]

Aquapel is the family name of a number of alkylketene dimers used for sizing. In most of our work we use one of these in various forms, tailored to operate best in the way in which we intend to use it. Aquapel 364 is the pure dimer, a waxy, white solid, m.p. 110°F. If the method of use calls for dispersion in water, an emulsifier is added; this product is designated Aquapel 380. To make a dry material for beater addition, the pure dimer is deposited on finely divided silica. One pound of dimer per pound of silica produces Aquapel 486, a water-dispersible dry powder. A recently developed form is Aquapel Emulsion 360, a water dilutable dispersion having 6% Aquapel 364 solids stabilized with (and in) a 3% solids cationic starch solution.

Aquapel is primarily a size for neutral or alkaline papermaking. One of the reasons why this sizing material was developed was the need for a size which could be used in paper having an alkaline filler; e.g., calcium carbonate. Conventional sizing with rosin-alum caused losses of the carbonate due to the low pH required. At best, efficiency of the rosin-alum was impaired by the carbonate, and delicate control was required to obtain sizing without too great sacrifice of the calcium carbonate filler. Aquapel, which does not need alum, or low pH was the answer. Then there was the desire to size (kraft-lined) jute test liner, without alum or acidity. Manufacturers of jute found they obtained 15 to 20% increases in burst if they made the board without alum, at pH 7 or higher. With Aquapel, the board was made under these conditions, sized to specification. These two uses still account for much of the current consumption of this new size.

Improvement of physical properties of paper and board through the elimination of alum and acidity opens a broad potential field. This improvement in physicals is more apparent when neutral or alkaline-prepared pulps are used; semichemical, unbleached and bleached kraft pulps are examples. The effect is not so pronounced with the acid-prepared pulps; i.e., groundwood and sulphite. As an example, it has been noticed that both types of pulp retain higher brightness on aging when made into paper at the neutral or alkaline pH. While this is a most interesting field for exploration, it is often difficult to abandon the idea that alum and acidity are essential to papermaking. Rosin-alum sizing has been in use for a century or more, and all our know-how, our equipment, and our various additives are conditioned or designed to operate with alum and low pH.

We have also seen improvements in the papermaking process, as well as the product, when neutral or alkaline conditions prevail. Obviously, corrosion can be greatly decreased, and less-critical pH control is required, especially where the pulps

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and water tend to be neutral. Sometimes we have seen faster drainage, and easier drying.

Aquapel is used for sizing against alkaline penetrants, such as silicate adhesives, coatings with casein of α-protein, high-pH printing, and writing inks. These not only penetrate rosin-alum sizing but also destroy it, lowering the over-all water resistance in subsequent use. Containers glued with silicate may lose sizing along the seams, then fail upon being wetted. Alkaline coatings might de-size lable stock or hanging paper so that pastes bleed through, causing staining. Certain writing inks may feather, and printing inks penetrate to give show-through, increasing opacity requirements.

Extremely hard-sizing is a "natural" for Aquapel. Liquid containers, like cups, bottles, and sipping straws, require considerable water-resistance. As a rule-of-thumb we would say Aquapel sizing should be considered if $5 or more per ton is being spent on conventional rosin-alum sizing. Because of its properties and its reaction with cellulose, Aquapel is better than rosin-alum for sizing to produce resistance to acids and alkalies and to solvent extraction.

Sizing jute test liner is easily done by calender waterbox applications of Aquapel 380 in water or starch solutions. Sizing other types of board by this method is limited by the depth to which sizing is required. In open, porous sheets, the dimer dispersion may penetrate 6 mils; in more dense boards, only 3 mils. The center of such a board may not have any water resistance. Where the end-use calls for exposure of the butt-edge to liquid, Aquapel must be used internally.

After some partially successful attempts to apply Aquapel to the surface at the size press or by spraying, efforts were turned toward internal addition of the dimer. The dry powder, Aquapel 486 was used as a beater additive. Retention of these fine particles then became the problem because normal grades of paper and board just were not efficient as a filter. In open white-water systems we lost much of what we added. Experiments however showed us that a cationic starch helped greatly. By adding the starch close to the machine, we estimated a retention of 75 to 85% of Aquapel 485. The same effect could be realized with dispersions of Aquapel 380 added continuously. Of most recent vintage is our Aquapel Emulsion 360, in which we have used this same cationic starch to stabilize dispersions of Aquapel 364 in water. The starch has a dual role; it is a stabilizer as well as a retention aid. This emulsion may be used on the surface or internally.

During the last four years Aquapel has become established as the preferred sizing agent for several grades of paper (e.g., jute line, type 3 repellent wadding) and is either being used or evaluated in a large number of other grades. As evidence that Aquapel can frequently do a better job at equal cost, the following cases are cited:

Mill Data on Aquapel Sizing

	Mill A		*Mill B*	
	Regular sizing	*6 lb. Aquapel 380*	*Regular sizing*	*5 lb. Aquapel Emulsion 360*
a. 21-pt. Bleached Kraft Milk Carton Sidewall				
L. A. Penescope, min.	204	546	55	300+
L. A. Cobb (g./sq. cm.)	0.47	0.27	0.40	0.24
Bursting strength, lb.	113	126	125	155

	Regular Sizing	*5 lb. Aquapel 486*
b. 9-pt. Bleached Kraft Cup-stock		
Boiling coffee, min.	90+	90+
L. A. Coffee, min.	12	57
Acetic acid, sec.	687	1800
Bursting strength, lb.	90	118

Lastly, follows a summary of the talk by C. G. Landes, American Cyanamid Co.

Accostrength Resin 2386 is a synthetic polymer designed to impart improved dry strength to paper without giving appreciable wet strength. It is an acrylamide-acrylic acid copolymer and requires the use of an aluminum salt for retention and proper functioning.

By use of 5 to 20 lb. of the resin per ton of paper substantial (10 to 50%) improvements in dry tensile and burst strengths have been obtained on all pulp furnishes except groundwood. In addition to fiber bonding, the resin often provides better drainage and drying, improved sizing and higher retention of fillers and fiber fines. These latter effects are probably dependent at least in part upon the flocculating tendency of the resin.

Maximum efficiency of the resin can be obtained by proper control of pH, amount of alum and ratio of alum to alkalinity in the system. Best results are believed to be obtained when the aluminum monohydrate floc is present.

Following the presentations the usual question-and-answer period was held.

MARIE M. MARTIN, *Secretary*

Golden Gate District

The Golden Gate District met at The Cottage in Oakland, Calif., on Tuesday, Dec. 2, 1958.

During the afternoon, open house was held at the plants of Western Waxide Corp., Longview Fibre Co. and Lord Baltimore Press. After the mill visits, 87 men were present at dinner and meeting at the Cottage Restaurant in Oakland.

An extremely interesting speech was presented by William Parle of the California Ink Co. whose remarks are published elsewhere in this issue of TAPPI. We then enjoyed a few words by R. G. Macdonald, secretary of National TAPPI.

It was announced that next year's dues would be $1.00 for National TAPPI members and $3.00 for Golden Gate District membership. The subscription to *Pulp and Paper* will be dropped but same can be picked up by members at the bargain price of $2.50 per year.

The next meeting will be held on Jan. 27, 1959, at the Hotel Claremont, Berkeley, Calif.

H. A. HARVEY, *Secretary-Treasurer*

Ohio

The Ohio Section of TAPPI met at the American Legion Hall in Middletown, Ohio, on Tuesday, Dec. 9, 1958. The membership enjoyed an interesting and challenging talk by Lowell Schleicher, head of the Fundamental Research Department at National Cash Register Co. in Dayton, Ohio.

The speaker has been associated with the National Cash Register Co. since 1951, at which time he graduated from the University of Michigan in colloid chemistry. He spoke to the group on the topic "The N. C. R. Paper Story."

Lowell Schleicher addressing the Ohio Section (TAPPI)

Virginia-Carolina Executive Committee: top row—Bill Ruffin, North Carolina Pulp Co.; Keith Bradway, Union Bag-Camp Paper Corp.; R. E. Bowyer, Chesapeake Corp.; R. H. Simmons, Bureau of Engraving & Printing. Bottom row—Robert E. Bowen, Continental Can Co.; R. G. Macdonald, National TAPPI; Ross F. Miller, Continental Can Co.; Ken Running, Halifax Paper Co.

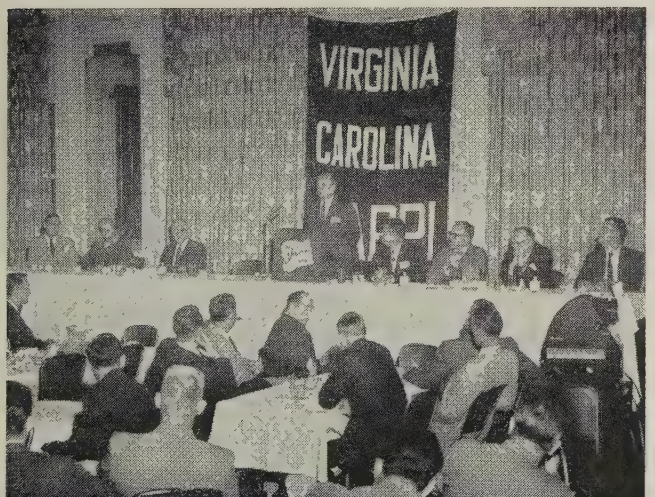
Mr. Schleicher emphasized the development of capsular structures in conjunction with their product, "No Carbon Required" paper. The speaker ably demonstrated diverse applications of the capsular development in the pharmaceutical, foodstuff, and fuel fields.

FRANK L. CESSNA, *Recording Secretary*

Virginia-Carolina

The first winter meeting of the Virginia-Carolina Section of TAPPI was held Friday, Dec. 5, 1958, at the Thomas Jefferson Hotel in Richmond, Va.

At the afternoon session the subject of continuous pulping was discussed by Reavis Sproull, director of technical services, Philip Morris Company, Richmond, Va., John McGovern, chief process engineer, Parsons & Whittemore, New York City, and Frank Vaughan, consulting engineer, Richmond, Va. Dr. Sproull discussed the subject from the chemist's viewpoint. Dr. McGovern discussed the cooking of hardwoods and vegetable residues by the various processes. Mr. Vaughan discussed the short continuous cook and the long continuous cook for both hardwoods and coniferous woods with particular emphasis on the equipment involved.



Head table at dinner: Reavis Sproull, Frank Vaughn, R. G. Macdonald, R. E. Bowen, R. F. Miller, M. M. Batzer, John McGovern, Jim Baker

The second subject for the afternoon session was "Black Stock Screening" which dealt with the screening of kraft stock in black liquor ahead of the washers. This paper was presented by Robert W. Wagner, assistant pulp mill superintendent, Continental Can Co., Hopewell, Va.

A business meeting was held to discuss future programs for the year. Present at this meeting were Robert E. Bowen, chairman of Virginia-Carolina TAPPI, Continental Can Co.; Ross F. Miller, vice-chairman of Virginia-Carolina TAPPI, Continental Can Co.; Jim Baker, secretary-treasurer of Virginia-Carolina TAPPI, Albemarle Paper Co.; Robert H. Simmons, Bureau of Engraving & Printing; Ken Running, Halifax Paper Co.; Keith Bradway, Union Bag-Camp Paper Corp.; Bill Ruffin, North Carolina Pulp Co.; M. W. Luthgens, West Virginia Pulp & Paper Co.; R. E. Bowyer, Chesapeake Corp.

A dinner meeting was held and after dinner M. M. "Smokey" Batzer presented his demonstration talk entitled "What's New in Fire Fighting?" He had visited the school building in Chicago where the recent fire tragedy had occurred and presented some pictures and made some observations on this subject.

Black Stock Screening

R. Wagner

I AM here to talk about black stock screening, and so there will be no complications, no misunderstanding, let's first define black stock screening. It is screen operation which takes place ahead of the brown stock washers or after the hot stock refiners, or we could call it hot stock screening or brown stock screening. It all means the same thing, and probably points to some small need for a standardization of terms in the kraft paper industry.

The operation is in many respects similar to conventional screening of washed stock, and uses very similar equipment. The operation takes place in much the same consistency range, has many of the same general problems, uses about the same plate size, hole spacing and has about the same method of handling rejects. One important difference, however, is the fact that with black stock screening you are much more susceptible to foam conditions, and the arrangement of the equipment is usually laid out in such a fashion as to do everything possible to prevent the entrainment of air and the formation of foam. The easiest way to do this is to put the screen in the pipe line, actually pump from the blow tank

R. WAGNER, Assistant Pulp Mill Superintendent, Continental Can Co., Inc., Hopewell, Va.

"Smokey" Batzer's after-dinner demonstration talk

Speakers at the Virginia-Carolina Section meeting: M. M. Batzer, Frank Vaughn, John McGovern, R. W. Wagner, Reavis Sproull

either through some refiners, or if your cook is soft enough without the refiners, but pump directly through the screen, after dilution to the proper consistency to the washers. The main difference here between black stock screening and washed stock screening is the fact that you are using pump pressure across the screen plate.

Much of the information used to compile this paper was taken on a trip which Mr. Miller and myself took to several kraft paper mills in the South who are either experimenting with black stock screening or already have put it into production. There are also some data from the various screen manufacturers and some information we have gained by talking to other people before and after the trip. These people are also interested in black stock screening. Now the reason for this interest in the industry in black stock screening is based on a number of factors.

There are several operational advantages to black stock screening.

First of all, you might say it is easier to operate a screen in this location due to the fact that you are using pump pressure across the screen plate, instead of a gravity head from an overhead trough of some sort.

Another operational advantage is that you are handling the stock a fewer number of times, not kicking it around so much in the process.

Third, there is a very definite power saving in screening in black stock than in washed stock.

Advantages of Black Stock Screening

1. Improved operation of pressure type screens
2. Less handling of stock
3. Power savings
4. No screen room operator required
5. Lower capital cost (a) more capacity per screen, (b) less building space required, and (c) less auxiliary equipment
6. Steam savings

Fourth, there may be some possible man power savings depending upon the specific problem in the mill involved. Some mills might not derive a man power saving by installing black stock screening, other mills whose organizational setup has grown up sort of topsy over the years might be able to cut out several by putting in black stock screening.

Another advantage is the lower capital cost required in setting up an installation of black stock screening that there would be in setting up a similar installation of washed stock screening with the same tonnage. This comes about by the fact that there are fewer pumps, a lot less piping, fewer motors, there are no deckers needed after the washed stock screening operation, no secondary screening system. All this contributes of course to a much smaller, less costly installation, and as a corollary to this lower capital cost the over-all square footage of floor space required for black stock screening operation is less than for washed stock screening, hence the building cost to house such an installation would be much less.

There is a possible fifth advantage which should be considered at this time. With the current improvement of high density stock pumps, the practicality of these pumps for operation in a kraft mill on a washed stock tank pumping high density stock directly to the paper mill without dilution is to be considered. This would increase the storage capacity of the present tanks, in terms of tons of stock, and would result in lower pumping costs by the elimination of a pulp mill white water system and all the necessary pumps involved in that.

Now what are the requirements for setting up black stock screening operation?

First of all you would need some suitable space, preferably in the area immediately ahead of the first stage washers. This area depending upon the number of screens required usually just matches out to the area that most people normally design into a building ahead of a set of washers. For instance ahead of a $11^1/_2$ by 20 washer, capable of handling 700 tons per day of stock, you would need three screens, and three screens take up about 22 ft. so the 20 ft. width of the washer plus the additional 7 or 8 ft. of drive on the back side just about matches up. Black stock screening will fit just nicely in most mills.

Second, unless the mill is cooking at a low permanganate number which is not the case in most of the southern kraft liner board mills, some sort of refining is necessary ahead of the screen. This may range all the way from one Claflin to a combination of Claflins and pressure refiners of Southerland breaker traps or whatever is available, but the refining is necessary to break up the large cards and the large knots into suitable size rejects for easy handling. If it is at all possible a complete refining setup ahead of the black stock screen will result in a much lower amount of rejects which have to be recycled back through the system.

Next, and probably the most important factor involved here in black stock screening, is an adequate consistency control which is also accurate. This is usually accomplished in a three-step procedure. The first step, generally speaking, is the conventional motor load controller operating off the blow tank agitator which reduces the blow consistency, say 8%, down to 4 or 5% for pumping from the blow tank to the refiners. Following the refining operation we would usually have a pipe line-type regulator. The DeZurik pipe line regulator works very well here, which takes a cut again on the consistency, and reduces it from 4% to something in the neighborhood of 2, $2^1/_2$, or 3%. This DeZurik regulator is usually set to hold that consistency very closely. Then we have a manually controlled addition of more black liquor to the closely controlled system coming from the DeZurik pipe line regulator to reduce this consistency for this screening operation. Now this screening operation takes place at a consistency which is usually suitable for the first stage washer. This would be then in the range of about 1 to $1^1/_2$%. Some people who like to run the first stage washer a little less than 1% might need to have additional dilution following the screening operation ahead of the washers.

Requirements for Black Stock Screening

1. Suitable space and location available
2. Hot-stock refining, soft cook, or adequate chip screening in wood room
3. Accurate consistency regulation ahead of screens
4. Suitable screens
5. Reject handling system

Next, you need some suitable type of screen which will operate effectively and efficiently in black stock. We will go deeper into this matter a little later on.

Next, you need some system for handling rejects. Rejects are customarily pumped back to the blow tank where they become part of the dilution in the cone, and are then recycled back through the refiners. Here again, if you have a complete refining setup for high yield, hot stock refining the amount of rejects is small and the number of passes any one reject might take through the system before being ground up is held to a minimum.

Now assuming that you have all the other requirements let's select a suitable screen. Table I shows the comparison of the three screens observed in operation by the writer on his trip, in which he has manufacturers' data and test data from other mills.

The first screen is a Cowan; this is the large size, the Mark A. Cowan. This screen has been converted from a conventional washed stock screen to a black stock screen and the mill in particular was operating seven of these screens. The tonnage was actually reduced from what it was on washed stock. Accept consistency ran about 1%, approximately 25% of the feed to the screen is kicked out in the reject line. No test data were available on the amount of good fiber in the rejects but it looked to be quite high. Reject consistency runs about $1^1/_2$%. The screen had about a 75-hp. motor and was using 110-cut plates.

The second screen observed in operation was a Black-Clawson Selectifier screen. Two sizes were in operation, one the 24 in., the other the 36 in. The large 36-in. screen, for which the data are given here on this table, has a capacity of 350 tons per day maximum. The accept consistency is 1.3%. The per cent rejects about 20% of the feed on this screen. No actual testing data were available on the good fiber in the rejects, but it looked to be about 75%, rough guess. Reject consistency was $2^1/_2$%. A 75-hp. motor on the screen and the hole size was 79 thousandths.

The third screen was an Impco screen. The screen observed in operation on the trip was one of the old original screens. It was modified and set up as a gravity screen ahead of the first stage of a fourth stage valveless washing system and operating on black liquor. The screen has since been redesigned and Impco has now put out a production model designed for 30 lb. pressure which operates as a flooded black stock screen. The screen has been successfully run at a 300 ton per day rate with an accept consistency of $1^1/_2$%. Only 10% of the flow is kicked out in rejects. Good fiber in the rejects is only 50%. Reject consistency is as high as 4%. The screen has a 100-hp. motor connected, and uses a 110-cut plate.

This gives you a quick over-all comparison of the three screens. The money involved we won't go into here. You can get your own quotes from the manufacturers.

To go back now and discuss each screen a little in particular.

Table I. Black Stock Screen Comparison

	Cowan	*Black-Clawson*	*Impco*
Net tonnage	200	350	300
Accept consistency	1.0	1.3	1.5
Rejects, %	25	20	10
Good fiber in rejects, %	—	—	50
Reject consistency, %	1.5	2.5	4.0
Motor horsepower	100	75	100
Hole size in plates, in.	0.110	0.079	0.110

First of all the Cowan screen. It is a rather simple matter to convert the Cowan to black stock screening. Conversion involves an extra heavy cover to be able to take the pump pressure, extra heavy clamps or cap screws to hold it on, a little better gasketing arrangement on the cover than normal. Also, additional packing rings are installed around the shaft and a special adapter is installed on the reject port in order to be able to fit a valve to it.

The writer is a little disappointed in the tonnage of the screen and the power requirements for that tonnage rate. The screen rotor generates a considerable amount of pumping head. The mill visited had made several experiments (cut out large parts of the rotor) to try to eliminate this but so far it hasn't been too successful. Cowan is aware of the problem, and their representative tells us that they are working on it. I hope they come up with something better in the near future.

The installation we observed was laid out in considerable detail with quite a number of automatic control valves all remotely operated, quite a lot of instruments and remote indicating pressure gages. They have gone all out to do a good job and give the screen every advantage. The screen normally operates with an inlet pressure to the screen of about 2 to 3 lb. The pressure is maintained by a butterfly valve on the inlet side of the screen. The rotor generates enough head so that the pressure of the accepted stock leaving the screen is held to about 10 to 12 lb. by the action of another butterfly valve in the discharge of the accept line. The rejects coming from the Cowan are held around 12 lb. pressure by the action of the butterfly valve in the discharge line. All these are remotely controlled in this particular installation by the washer operator at the washer control panel. The inlet valve on the screen is set to close when the pressure differential across the screen drops to 3 to 4 lb. This would indicate that the screen is blanking off and plugging up with stock. It is interesting to note that when they start the screen up on nothing but black liquor and haven't added any stock to it yet, the motor load goes clear up way off the scale. Their 75-hp. motors pulled over 250 amp. when running nothing but black liquor through the screen. Gives you some indication of the amount of pumping head that rotor will develop. When the stock hits the screen, then of course it seals over the plate and in a sense throttles the pump down, cutting down on the motor load. I don't know what Cowan can come up with but certainly there is some room for improvement in the operation of this screen on black stock.

Black-Clawson has taken their standard Selectifier screen and tried it out on black stock. There are a good many of these screens in operation in board mills, waste paper mills, etc., all over the country. The mechanical bugs have been worked out of them. It is a very sturdy, rugged looking piece of machinery. They have just taken their straight screen and with one or two minor changes have adapted it quite easily to black stock screening.

Two mills, in particular, are working with this screen. The one with the 24-in. size, and they have accepted the screen as being practical and have installed five of them ahead of two lines of washers, and at the time of our visit had three more screens they were preparing to install ahead of their third line of washers. They like the operation and are making this installation in order to be able to eliminate a screen room over in the paper mill and thus save man power, pumping costs, and realize all the other advantages mentioned earlier on black stock screening. The larger 36-in. screen has been tested and proved satisfactory in another mill. They are currently not operating this screen as a black stock screen; however, they are considering, when money becomes available, installing some of these screens to replace their present washed stock screen room.

The principal operation of the Black-Clawson screen is well tested, the hydrofoil vanes seem to do a very good job in keeping the screen plate clean. The operators at the mill using the 24-in. size felt there were very few problems connected with the operation and were quite satisfied with it.

The Impco screen is another adaptation involving the redesign of their conventional wash stock screen so that it can take up to 30 lb. pump pressure. The screen gives a

clean looking installation, all the piping just about can be below the floor. The rejects come off at a good high consistency, are easily handled and contain the smallest amount of good fiber of any of the three screens. I understand that since we have made the trip, a mill down south has purchased nine of these and is going whole hog on an installation of black stock screening.

The data pretty much speaks for itself. Draw your own conclusion. I'm sure all the manufacturers involved in this are quite willing to come in and talk their brand of screen with you.

Now let's see what is possible to do in one particular mill with black stock screening. To make it really easy I will talk about the mill I am most familiar with, the one in which I work. We have in operation in our washed stock screen room which was just built and put in operation a little over a year and a half ago six large Cowan screens on primary screening, two Mark E. Cowan Screens on secondary screening and an assortment of reject tanks, agitators, white water pumps, accept pumps. We have four deckers and two reject refiners. Our stock system is divided into a hard side, cooking at a permanganate number of about 50 to 52 on a 75-ml. test and a soft side cooking about 34 on a 75-ml. test. We normally have running 1480 hp. out of 2380 hp. connected.

If we were to install a system of black stock screening ahead of our two lines of washers, one line on hard stock and one line on soft stock, we would put in four or five screens, a couple of reject pumps, probably use our present consistency regulators. All in all, we would put in about 500 hp. Now this would then result in a saving of about 890 hp. I have not included in this the 600 hp. used to refine rejects in the washed stock screen room, since rejects are going to take about the same amount of horsepower whether they are refined in a black stock or a washed stock operation. The rejects would merely be recycled in the black stock screening operation back through the refiners ahead of the screens; the horsepower would still be consumed, in a different place in the process. Now this savings in horsepower amounts to about 667 kw.-hr. and since at our mill we purchase a large amount of outside electric power at nearly 9 mills a kw.-hr., this amounts to a saving of about $141 a day or $4230 per month. Based on our tonnage, it amounts to about 21¢ per ton. Now that is a pretty substantial cost reduction. Based on the current quoted price of a black stock screen, we would pay for an installation of black stock screens in about 14 months time, and would then be able to credit this power savings against our pulp costs.

We would in our particular case eliminate a screen room operator, run the operation from the blow tank clear to the high density storage with two men per shift; a washer operator on each line of washers. These men would operate the hot stock refiners consisting of three Claflins, five 440-Bauers, five black stock screens, and two lines of three stage washers without any other additional help. This is quite a savings in man power, a cut of a third. Then in our particular case the area taken up by the present washed stock screening operation would be made available for future expansion by the installation of an additional line of washers.

To summarize briefly:

1. Black stock screening is on the threshold. It will find more acceptance in the industry. Equipment and methods will continue to improve because of the great amount of knowledge of screening already gained in the washed stock operations.

2. Yet to be evaluated completely are its effects on washer performance, salt cake losses, alum consumption, wood yields.

3. Other developments in the offering might greatly reduce the amount of rejects in the stock going to the screens; for example, chip breaking.

4. Fiber classification on a mill scale operation and elimination of separate stock system for secondary headboxes is a definite possibility.

5. Equipment is available now that is especially designed for black stock screening.

6. With this equipment it is possible, even at the present state of development and technique, to install black stock screening and realize many benefits from this type of operation.

7. The economics of the method argue strongly in favor of black stock screening.

Presented at the meeting of the Virginia-Carolina Section of TAPPI, held in Richmond, Va., Dec. 5, 1958.

Empire State Section, Executive Committee Meeting: front row—Fred Sommerville, past-chairman; Wayne Morrow, chairman; Gordon Storin, past-chairman; Bill Willets, past-chairman; William Rice, 3rd vice-chairman; Roy Sullivan, secretary-treasurer. Back row—Jack Parsell past district chairman; Bob McPheters, district chairman; Bob Blakeslee, past district chairman; Horace Spencer, finance executive; Grant Cole, past-chairman; J. V. Wolff, assistant treasurer; E. F. Hudson, past district chairman

Empire State

Empire State Section of TAPPI held its annual meeting at Whiteface Inn, Lake Placid, N. Y., June 12–14, 1958. An attendance of 272 was very gratifying to the officers and committees, after the effort they put forth to present a first class technical and social program.

Graphic Arts Session: R. B. Blakeslee, Imperial Paper & Color Corp.; O. C. Holland, Inter-Chemical Co.; D. R. Hall, Instrument Development Laboratory, Inc.; J. F. Storm, Bausch & Lomb Optical Co.; M. Bosah, J. W. Clements Co.; M. Cattaro and W. M. Westgate, Gardner Laboratories

Empire State Jr. Awards Papers: J. G. Rice, Lowe Paper Co., chairman. Award winners: A. F. Bobreski, Sealright Co.; R. J. LaFond, St. Regis Paper Co.; R. A. Boss, Marinette Paper Co. Judges: Horace Spencer, Knowlton Bros.; J. J. Forsythe, International Paper Co.; W. R. Willett, Titanium Pigment Corp.

The technical program was extended into Saturday afternoon this year. This allowed four half-day sessions. The attendance through all sessions was above average, which probably reflects the fact that if a good technical program is prepared there will be interest developed.

The social activities were enhanced by fair weather and the ever-increasing number of wives attending. A new feature this year was the midnight barbecue on Friday. Either this activity kept people up, or it is surprising how many people are still up at midnight if you get them all together in one place. The quality of the food was also gratifying. This was the second year for bowling, with more participants than the first year, which is following the national trend in this sport.

The Saturday evening banquet was highlighted by "Woody" Geffken's dry wit as toastmaster and his presentation of gifts. A second interesting event was the revival of an old tradition by Chairman Grant Cole, when he presented the Empire State Charter to the incoming chairman. It was also through Grant's efforts that the charter was put up for display during the meeting.

One of the important official announcements resulted from the balloting on whether to split the Secretary-Treasurer office into two separate offices. The voting members said yes, to split. The executive committee meeting promptly appointed J. V. Wolff, Nopco Chemical Co., Harrison, N. J., as assistant treasurer until a permanent treasurer is elected next year.

The Section has set dates for holding this convention at Whiteface Inn for the next 4 years. The dates for 1959 are June 11–13.

Semichemical Pulping of Hardwoods

Raymond H. Taylor

A MORE appropriate title for this paper would be, "Semichemical Pulping of Hardwoods as Practiced at Finch, Pruyn & Co." There are too many ways of manufacturing this type of pulp to hope to be able to cover such a broad topic as this in one talk. Actually our personnel at Finch, Pruyn became actively interested in this type of pulping only about 2 years ago, and our mill has only been in operation for 8 months. We still have many problems which are unsolved and needless to say we are learning every day.

We believe that our choices of equipment and our methods of operation are basically good. A major reason for this is all the help we received from others in our industry who have far more experience in this field than we do. To these people we extend our heartfelt thanks.

WOOD SUPPLY AND HANDLING

At the present time we are receiving roughly 20% of our wood supply in the form of purchased chips, and 80% we bark and chip right in our woodroom. We are limiting the species of wood used to birch, beech, and maple, and originally wanted to use an equal proportion of each wood but our method of cutting in mixed or pure stands makes this impossible. Because of this the pulp going through our plant contains just about any possible proportion of these three wood species and so far we have been unable to find any reasons to feel that this is undesirable. We are planning in the near future to have an extended run on each species separately, to judge the affects throughout the process.

Due to our methods of wood procurement here in the north, it is necessary to have a larger wood supply on hand than most southern mills. We are trying to keep no more than a 6-month inventory on hand. Wood much older than this tends to become more difficult to bark, chip, cook, and bleach.

Our wood is wet barked in a 12 by 45-ft. drum barker which was already in use on softwood for the groundwood mill. Barking capacity is, of course, affected by the season, type of wood, and the length it has been stored. Presently we are running at about an 8 to 10 cord per hr. rate. The 4-ft. sticks discharge onto a reversible belt conveyor which either carries the softwood to the groundwood flume or the hardwood to the chipper, with logs not completely barked being recycled back through the barker.

We have learned that chip size in our process is of the utmost importance in order to insure adequate penetration of cooking liquor in digestion. We are trying to make a $^1/_2$-in. chip and a typical analysis of our mill chip sizes as found on a Williams chip classifier is as follows:

1-in.	1.3%
$^3/_4$-in.	7.1%
$^1/_2$-in.	55.2%
$^1/_4$ in.	31.4%
$^1/_8$-in.	4.4%
through $^1/_8$-in.	0.8%

Hardwood Pulping Session: J. W. Lorey, Forestry College Syracuse University; R. H. Taylor, Finch Pruyn & Co.; R. D. McPheters, Gould Paper Co.; G. H. Tomlinson II, Howard Smith Paper Mills Ltd. and J. G. Bryce

RAYMOND H. TAYLOR, Neutral Sulphite Mill Supt., Finch, Pruyn & Co., Inc., Glens Falls, N. Y.

As you can see, about 90% of our chips are retained on the 1/2, 1/4 and 1/8 in. decks and this gives us a uniformly small chip which we find most desirable.

We have an 84-in., 10-knife chipper powered by a 300 hp. direct connected synchronous motor. Up to 15 cords per hr. have been run through this chipper, and it will accept logs up to 14 in. in diameter. Logs larger than this are split on a 30 in. by 5 ft. hydraulic splitter. From here the chips are screened on a triple deck vibrating screen with any chips over 3/4 in. being put through a rechipper and recycled back to the screen.

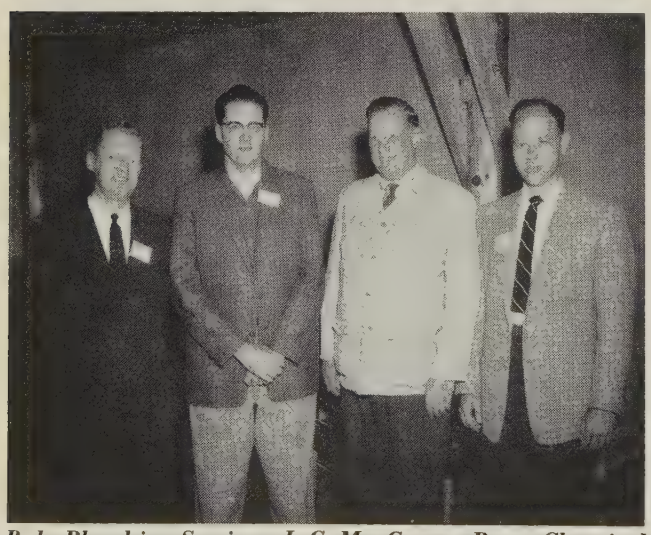
Our purchased chips arrive in trailer trucks and are unloaded with a vacuum system and rescreened. From the woodroom, both the purchased chips and our own chips are conveyed pneumatically a distance of 400 ft. to a chip silo. Chips falling off the accept decks on the screen drop into a pocket feeder which controls the feed to the 10-in. chip deliver line which conveys the chips by air supplied by a 4500 c.f.m. blower unit. This chip line discharges into a 30 ft. diam. by 65-ft. high tile chip silo which has a capacity of about 20,000 cu. ft. or 100 cords of chipped wood. This silo was designed with a capacity to furnish our digester with wood for a 24-hr. period.

COOKING

Our digesting vessel is a 3500 cu. ft., vertical, stationary digester, with dimensions of 11 ft. diam. by 49 ft. high. Because of the highly corrosive nature of neutral sulphite cooking liquors, we had our digester clad with a 316 ELC, S.S. lining. This precaution was also taken with our blow tank, and all the piping in the brown stock end of the plant is also 316 S.S. Our experience so far indicates that this was a wise decision and in the long run will save much money and downtime.

Digester charging time runs 15 to 20 min. Chips are removed from the silo by a rotary table feeder and conveyed by means of three rubber belt conveyors and a bucket elevator to the digester. One of these belts is equipped with a weighing instrument, and all the cooks have to do is set the desired tonnage to be charged, start the system up, and when this weight is reached all conveying equipment shuts off automatically. The cooking liquor is then charged automatically and the digester is capped with an automatic charging valve. Fully charged the digester holds about 24 tons of moisture-free chips, or about 17 cords of wood.

Our cooking liquor is a sodium sulphite solution buffered with sodium carbonate. At present we are making the liquor up to a concentration of 1.65 lb. per gal., as Na_2SO_3, and a



Pulp Bleaching Session: I. C. MacCugan, Becco Chemical Div.; Grant Cole, Finch Pruyn & Co.; W. H. Monsson, Hooker Electrochemical Co.; R. S. Painter, International Paper Co.

Paper Machine Session: E. F. Hudson, Lowe Paper Co.; J. C. Parsell, J. P. Lewis Co.; W. S. Corbin, Black Clawson; W. E. Carlson, St. Regis Paper Co.; J. R. Redgrove, Beloit Iron Works

4:1 ratio of Na_2SO_3:Na_2CO_3. Enough fresh liquor is added to the digester to give 19% Na_2SO_3 on the weight of the wood, and spent liquor to give a 3.5:1 ratio of liquor to wood completes the charge.

The digester is equipped with a circulation system, which withdraws liquor from a center strainer and circulates it to both the top and bottom of the digester. An external tube-type heat exchanger is used to heat the liquor, and the whole system is quite similar to a standard forced circulation externally heated digester quite common in the industry. Heat distribution throughout the digester is quite good, as evidenced by temperature bulbs mounted in three different sections of the digester.

Cooking control is completely automatic, and controlled by pressure. Both relief and blowback are also automatic, and all steam is added through the heat exchanger. At the present time we are cooking at 120 p.s.i.g. pressure, taking 2 hr. to come up to temperature and 1 3/4 hr. at temperature. At the end of this time the digester is blown at full pressure into a blow tank which has a capacity of about three blows in the straight sides. We are now making a number of changes in our cooking procedures and conditions, and I am certain that a few of the conditions mentioned above will soon be changed.

From the blow tank on through the rest of the system the process is a continuous one. For this reason it was necessary to install fair size storage units between each stage to try to insure a continuous operation which would not be affected by minor shutdowns in any one particular stage.

BROWN STOCK OPERATION

Unlike kraft and sulphite cooks, the resulting pulp from a neutral sulphite cook is still in the form of chips and for this reason some sort of mechanical refining must be resorted to. For this purpose we chose two Bauer, no. 410, double disk refiners, each powered by two 400-hp. motors. Our method of handling the chips which are fed to the refiners is quite different from the majority of installations in the country, and it was in this section of the mill that we experienced most of our startup difficulties.

From the blow tank chips are diluted with black liquor and pumped up over the refiner feeders with an excess returning back into the bottom of the blow tank. Diluting the chips down to pumping consistency (10 to 14%) is controlled by the blow tank agitator load. Two variable speed pocket-type feeders are used to meter the chips to a small inclined rotary dewatering screen which is used to remove excess

Presentation of Empire State Section Charter from outgoing chairman to new chairman. Outgoing chairman, Grant Cole, Finch Pruyn Paper Co., and new chairman, J. Wayne Morrow, Newton Falls Paper Mill

black liquor and even out the consistency of the stock going to the refiners.

Before the chips drop into the refiners hot black liquor is added to them to give a refining consistency of 11 to 13%.

As I mentioned before, we experienced a good deal of difficulty at startup time in handling our chips. The piping layout and the blow tank dilution are quite critical because these chips dewater rapidly resulting in serious piping plug ups. It was necessary for us to make a number of changes before we came up with our present setup which I believe is one of the most compact and maintenance free of any in use on this type of pulp in the industry.

The refiners are run in parallel to give a pulp of about 550 ml. C.S. freeness, and hourly tests are run on freeness, and handsheets are made up for visual inspection of shive content. Low freeness and shives are two of the biggest problems in the manufacture of a bleached semichemical pulp and for this reason quality control in this area of the plant is quite important.

The resulting pulp from the refiners is diluted down to pumping consistency with dilute black liquor and drops into an agitated chest which serves as a supply for our brown stock washers. Before washing the stock it is diluted down to screening consistency and pumped through selectifier screens and then to the washers. The screens are equipped with 0.050-in. perforations and rejects are continually bled from them. These tailings are then put through Bauer 606 cleaners with the accepts going back to the screens, and the rejects being sewered.

From the selectifier screens the accepted pulp goes to the first stage brown stock washer. Our washing installation is a conventional two stage countercurrent system using 8 ft diam. by 16 ft. wide 316 S.S. washers. We are using 140°F. wash water on the second washer at a rate of $2^1/_2$ to 3 g.p.m. per ton per day of pulp. We recover heat from our spent liquor and this along with our digester condensate gives us this quantity of hot water which enables us to do a good washing job with low steam consumption. Washed pulp from the second brown stock washer, at 13% consistency, is then conveyed to a high density brown stock storage tower which is just before the bleach plant.

BLEACHING

The methods, and equipment used in bleaching semichemical pulp to an 80 brightness range are quite similar to that used on sulphite pulp, and our plant is no exception. Our bleachery consists of a three-stage system using chlorination, caustic extraction, and sodium hypochlorite stages to complete the purification of the pulp. We bleach to an 82 G.E. brightness, which we have found to be sufficiently high for use in our groundwood grade papers.

Chemical usage in semichemical bleaching is much higher than in the bleaching of sulphite pulps. At the present time, we are using 15 to 16% Cl, 4% NaOH, and 1.5% NaOCl, all chemical percentages being based on unbleached, overdry pulp to the bleachery.

One variation we have used in our bleach plant is our method of screening the bleached pulp. The discharge from the hypo tower is pumped to a blending chest where it is diluted down to 0.5% consistency and pumped through 30 Bauer No. 606 Centri · Cleaners to the hypo washer. These primary cleaners are equipped with water eductors which prevent air from entering the accepted stock and lowering the washer capacity. Rejects from the primary cleaners are then handled in a conventional manner in four secondary cleaners.

From the hypo washer the bleached pulp is conveyed to a 50-ton high density storage tank at 11%. This tower is equipped with mining nozzles, an agitator, and a recirculation system which are used in conjunction with a consistency regulator and a blend chest to supply 3% stock to the paper mill.

CHEMICAL HANDLING

In our process it is necessary to handle or makeup chlorine, caustic soda, sodium hypochlorite bleach solutions, soda ash, and buffered sodium sulphite cooking liquors.

In the handling of our main bleaching chemicals, chlorine and caustic soda, we use equipment that is quite standard throughout the industry. Of interest, however, is the method with which we make up our bleach solution. We use an oxidation reduction unit, and so far have had no trouble in maintaining a close control on our hypochlorite strength. In place of the many large storage and make-up tanks which were necessary in the old batch made-up systems we have a 7 ft. diam. by 12 ft. high rubber-lined tank, two small pumps, and two instruments. This system has run almost unattended since startup time except for minor corrections by our instrument men.

To lessen our startup problems, and also because our final maximum capacity has still not been set, we did not install sulphur burning equipment and abosrption towers to make up our cooking liquor. We started up on a liquor made up by bubbling liquid sulphur dioxide into a soda ash solution to form the sodium sulphite cooking base and then buffering the solution with soda ash. For the past 5 months we have been buying sodium sulphite in hopper cars and unloading it by means of a vacuum system directly into the old sulphiting tank where it is dissolved in water. Soda ash is then added to bring the final solution up to the correct ratio of Na_2SO_3:Na_2CO_3. We receive our soda ash in 35-ton hopper cars and unload it also by a vacuum system. This storage has a capacity of 300 tons stored in slurry form. This slurry storage system of soda ash has operated quite well for us since startup time and we unload a 35-ton car in about 4 hr.

PLANT CAPACITY, LAYOUT, AND PERSONNEL

Because there are so very little operating data available on the capacities of such items as washers, digesters, and refiners operating on a fully bleached semichemical pulp, the figure of 70 tons per day of moisture-free bleached pulp was an educated guess. Our experience to date has proved this guess to be a good one. We have run at this rate for a few 24-hr. periods when paper mill usages have called for it and have experienced very little operating difficulties. The design of the mill is such that with very few changes, and the installation of a few more pieces of major equipment such as a

digester, and refiners the plant capacity may readily be doubled.

Uppermost in our minds during the design and layout stages of the plant was the fact that we must keep the operating personnel in the mill to a minimum. By carefully locating equipment and installing well planned and completely instrumentized systems, I believe we have accomplished this. Our brown stock system is operated by one man who handles and controls the digester, refiners, and brown stock washers. Our other operator runs the three-stage bleach plant, chlorine and caustic systems, and also the equipment which supplies the bleached pulp to the stock preparation department. Also on each shift we have a foreman who has charge of the plant, and a tester who runs all chemical and physical tests for both the brown and bleach stock operators. One shift per day we have a chemical handler who unloads and makes up cooking liquor.

CONCLUSION

After eight months of operation, management at Finch, Pruyn definitely feels that they made a wise decision in installing our new hardwood mill. With the use of larger percentages of a strong, fully bleached, chemical pulp in conjunction with groundwood, we have definitely upgraded all of our printing and converting grades of papers. This has been a very important factor in keeping our company in a competitive position in this semidepressed period.

Presented at the meeting of the Empire State Section of TAPPI held in Lake Placid, N. Y., June 13–14, 1958.

Kalamazoo Valley

The Kalamazoo Valley Section held its second meeting Nov. 6, 1958, at the Harris Hotel, Kalamazoo, Mich. Chairman, E. E. Stephenson, Jr., Sutherland Paper Co., of Kalamazoo, presided over the meeting. Program chairman, W. O. Kroeschell of Michigan Carton Co., Battle Creek, Mich., presented the speaker for the evening, James E. Overall, pulp and paper industry manager, Fischer and Porter Co., Hatboro, Pa.

P. Dean Graham, Jr., *Secretary*

The New Concept in Consistency Control—A Progress Report

James E. Overall

It is likely that most of you are aware that within the past year the industry has had the opportunity to put into general use a consistency regulator of radically different characteristics from those of earlier periods.

The purpose of this paper is to present a brief and factual report on how the new unit has fared under mill operating conditions since it was introduced. Fortunately, the locations chosen for the installations were seldom ideal, and the results have been such that either the inadequacies of competing systems were made quite apparent or, the one weakness of the new system made the installation temporarily worthless. It is hoped that the candid treatment of the three failures may help you to accept more readily the strikingly good results at some 14 other installations to date.

As some readers are aware, the author is in the uncomfortable position of having specified, purchased, installed, and "lived with" more consistency control systems of competitors' manufacture than his present employer has marketed. Happily, this condition will have been corrected by the time this paper is published. This background should be borne in mind, however, if it appears later that comparisons unduly favor the new approach. In recognition of the opportunity

James E. Overall, Pulp and Paper Industry Manager, Fischer & Porter Co., Hatboro, Pa.

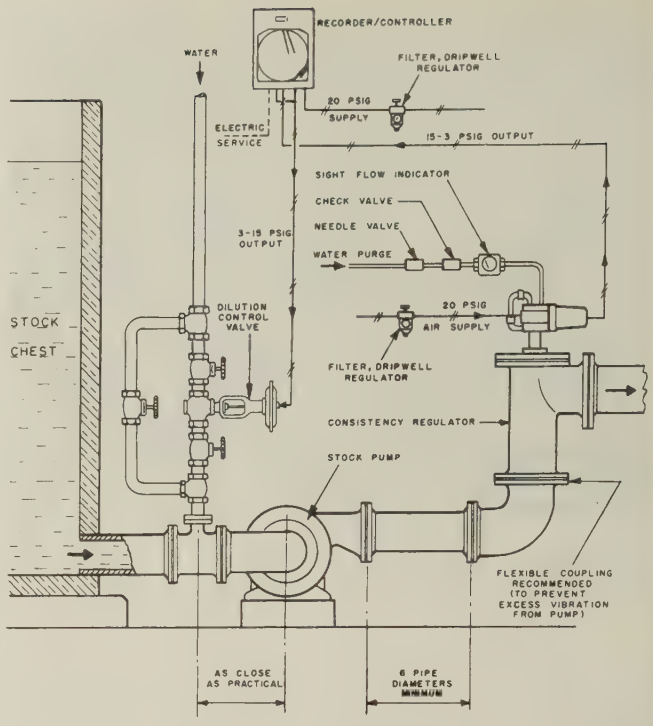


Fig. 1. Typical installation

afforded in making this report, every effort has been made to eliminate bias in arriving at conclusions.

To provide well-defined areas of interest, the body of the report has been divided into the following sections, all referring to the new consistency control method: (1) what it is; (2) why it works; (3) where it works; (4) where it faltered; and (5) what next?

WHAT IT IS

The Fischer & Porter In-Line consistency regulator is the first commercial application based upon a new and important physical characteristic of pulp slurries, namely, shear, briefly defined as deformation produced by shearing stress. Isolation, definition, and measurement of this new parameter of stock slurry hydraulics represents one of the major achievements of the TAPPI Hydraulics Committee; Head (*1*) reported in 1952 some of the first evidence of stock shear as a significant phenomenon, and in 1957 Head and Durst (*2*) published a summary of the findings of the committee on this subject, including new terms and new equations which served to rationalize observations heretofore inexplicable by classic analyses. The important point to be noted is that stock shear emerged as a distinct concept quite apart from any relationship to the sliding friction of a stock slurry upon a surface. If there is a key word here, it is "deformation," or the movement internally of stock fibers upon stock fibers.

Physically, as can be seen in Fig. 2, the consistency sensing and transmitting unit is a pipe tee with raised side outlet, containing and supporting a shear-producing central element, which comes into contact with one side of a differential pressure transmitter, Fig. 3, transmitting to it the shearing forces which have been imparted to the shaft of the "war club." These forces are created by successive deformations of the stock stream as it passes around the projections, or fingers, or the club body. It is important to note here that the club does not turn, and no torque is present. Literally, the fibers in the stream are pulled apart by the fingers, and the force required to do this becomes the primary measurement for the remainder of the system, in the form of a 3 to 15 p.s.i. pneumatic signal.

WHY IT WORKS

Now at precisely this point comes the hardest part of gear-

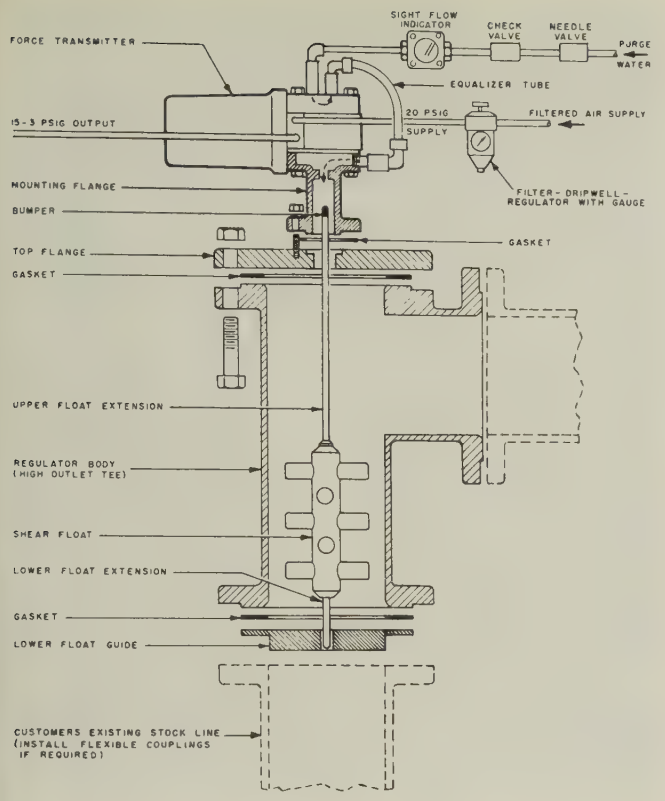


Fig. 2. Order of assembly

ing our thinking to the new concept, shear, without being unconsciously, but completely, swept off course by our previous familiarity with sliding friction. While it is quite true that sliding friction forces are present in the situation at the "war club," shearing forces are so accentuated by the club configuration that it is possible to ignore the effects of impact and of sliding friction over ranges of stock flow from 10 to 1, to as high as 30 to 1 in the larger size units. A simple analogy originated by Head may be given here to illustrate this point more clearly. Let us suppose that we had available a short length of 6-in. pipe, and a cylinder of lead that would fit in this pipe quite closely. With lubrication, the lead cylinder could be pushed through the pipe by application of a relatively small force. If, however, we inserted a 1-in. steel bolt through the pipe and then forced the lead cylinder to deform or shear around the bolt during a second passage through the pipe, the amount of force thus required would become fantastic. It is

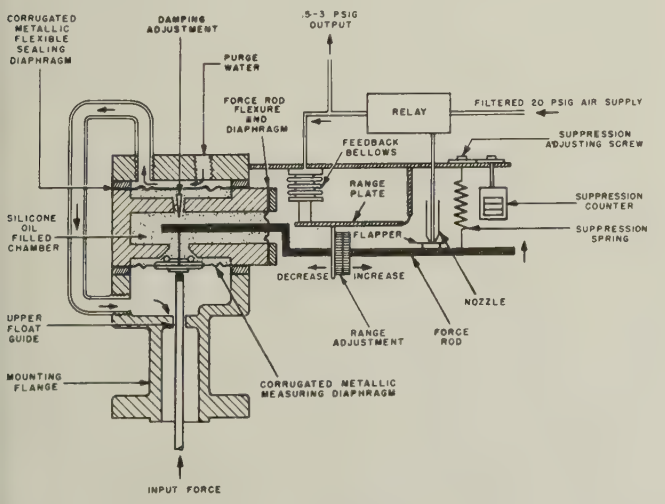


Fig. 3. Model 50FB1010, force transmitter, operational schematic

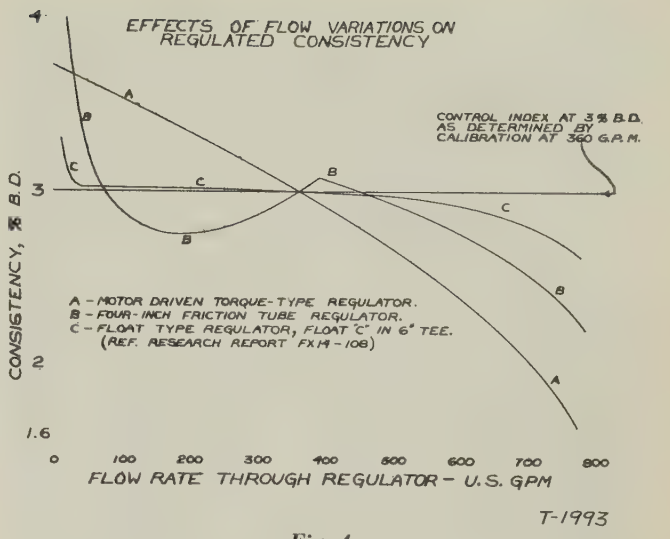


Fig. 4

this difference in magnitude of forces that we make use of in measuring and using the shearing stresses in a stock stream as compared to the also-present sliding friction forces.

It may be stated that in the past, consistency regulators measured and transmitted sliding friction forces, by means of flow boxes, sections of pipe, or paddles revolving in the stock stream. The present concept departs from these, and utilizes the almost infinitely greater forces available through controlled shearing of the stock stream.

Finally, to illustrate the extent to which rate of flow does affect earlier methods and does not affect the new method, let us consider Fig. 4 (T-1993), borrowed from one of our research reports. On this plot are shown the calculated effects on three types of unit, where a constant consistency of 3.0% is assumed, and the rate of flow through the units is varied from zero to 775 g.p.m. The illustration is most effective if we assume that control within the usual 0.1% consistency is required. Type A is seen to be capable of control between 315 and 405 g.p.m. or about 1:1.3 flow span. Type B actually has two different control points, but at the best one, the range is 315 to 515 g.p.m., or 1:1.6 flow span. Type C, the war club, ranges from 20 to 615 g.p.m., or a span of better than 1:30. In practice, the performance of types A and B can be improved to at least 1:2 by careful attention to design details, but the marked superiorty of the type C remains.

WHERE IT WORKS

This paper is intended to provide only a quick review of the foundations of the new concept, plus a general statement of what has occurred in representative situations. It is anticipated that one or perhaps several users will later report in detail their experiences on specific difficult or unique applications. The comments that follow will therefore be given only in terms of type of pulp, type of application, and locality.

A. Wisconsin, 240-ton mill, sulphite and groundwood; one unit in operation year and a half, "control better than 0.1%;" "much superior to competitive unit."

B. New York, fine paper mill; oue unit in operation year and a half, recording results of control by other means.

C. Ohio, 600-ton mill, kraft and sulphite; three units ranging 1 to 2 years, "control better than 0.1%; wide flow ranges."

D. New Jersey, 170-ton mill, kraft and sulphite; one unit operating less than year on several applications, "control very good, better than previous unit."

E. Japan, tonnage not known; unit in operation about 6 months, no report, but second unit on order.

F. Canada, sulphite mill; one unit in operation about 8

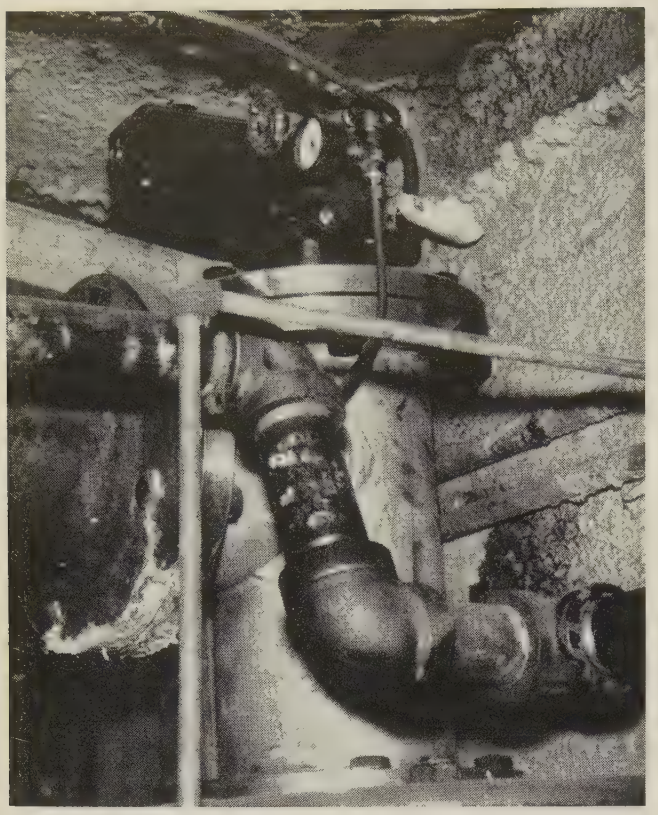


Fig. 5

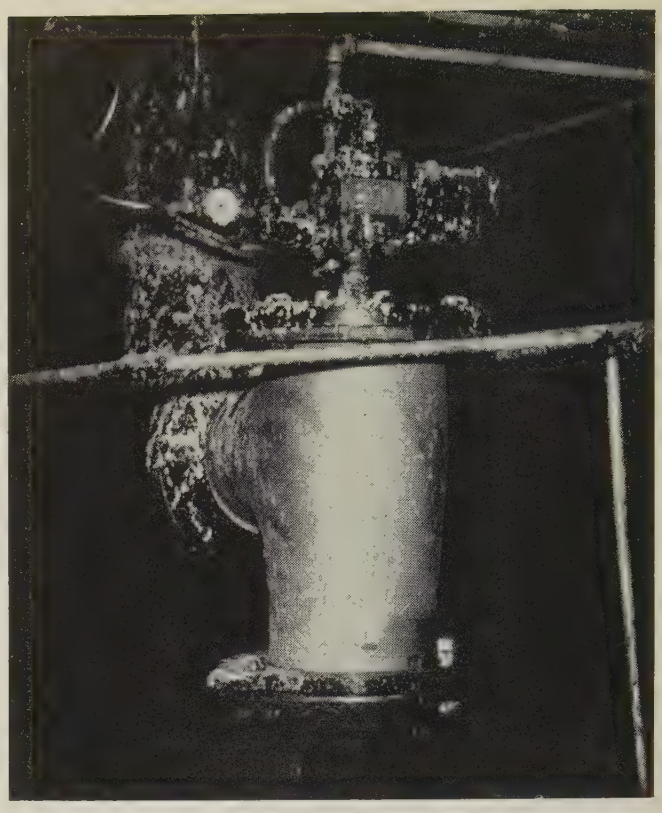


Fig. 6

months, initial difficulty due to short fiber and consistency near 2%, now doing better job after extending war club fingers. Situation not suited to other types of regulation.

G. Indiana, 125-ton mill, semichemical; one unit in operation about 6 months, good control, but occasional upsets related to some condition in complex piping system.

H. Pennsylvania, 300-ton mill, kraft; one unit in operation about 4 months, primarily useful in recording conditions at high density storage tank; system possibly not controllable with present mining nozzle settings.

I. Michigan, 400-ton mill of Consolidated Paper Co. at Monroe; three units on control, fourth unit being installed. Product primarily automative panel board. Because this paper is for presentation to the Kalamazoo Valley Section of TAPPI, the Monroe installation has been selected for more detailed coverage, in the accompanying photographs.

Figure 5 shows the 8-in. unit used in the filler stock system, and is included here to illustrate the ability of the unit to function in well-nigh impossible situations as regards piping and space. You will note that the ceiling, a wall, a beam, and the dilution water line, are all within less than a foot of the unit. Yet, the size and weight of the unit are such that two men could readily remove or replace it quickly should it ever become necessary. The initial operating adjustments are made at the transmitter unit visible at the top of the photograph.

Figure 6 shows one of the 8-in. units typical of the other three systems. The photograph is included here to emphasize the immunity of this type of consistency regulator to overflows and wash-ups; there are no moving parts, no electrical connections, and there is no risk of contaminating the stock with foreign fluids.

Figure 7 shows two controller charts from the filler system shown in Fig. 5. The left chart is "on control" while the right chart was obtained for us by George Lockwood, the plant engineer, by shutting off control purposely for one day. Deviations in consistency ranged between 2.7 and 3.7% during this period, with less than 0.1% deviation when control was resumed.

Figure 8 shows a preliminary study period on the bottom liner stock system. You will note that this system is subject to much more pronounced changes in consistency. This system is now also under satisfactory control.

Figure 1 shows the schematic arrangement of the units at Consolidated Paper Co., and is typical of the majority of installations elsewhere. Two points should be noted here: (1) the fact that the sensing unit is quite near the pump permits very fast control response; and (2) location of the unit below chest level prevents dewatered stock from accumulating during shutdowns, and as a result, no units to date have plugged. This illustration also serves to emphasize that the units are normally used on the entire stock stream; for example, a 12-in. size (tee) will pass a flow of 4500 g.p.m.

WHERE IT FALTERED

As with all new products, some flaw was certain to develop eventually, but in this case, it did not appear until nearly two years after the first mill installations. The application causing trouble in all three cases involved rapid loading and unloading of the force unit, which is a slight modification of our differential pressure transmitter. The intermittent loading came about on two applications where on-off stock flow oc-

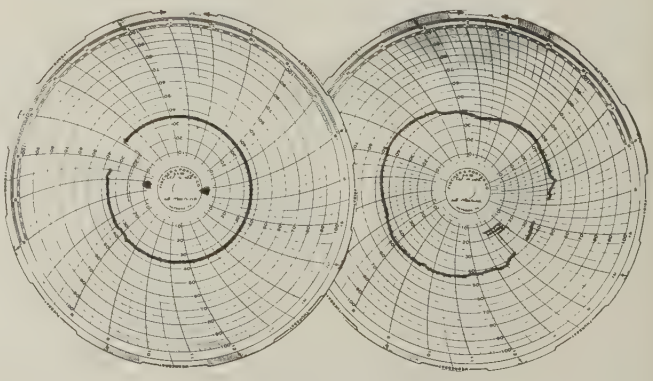


Fig. 7

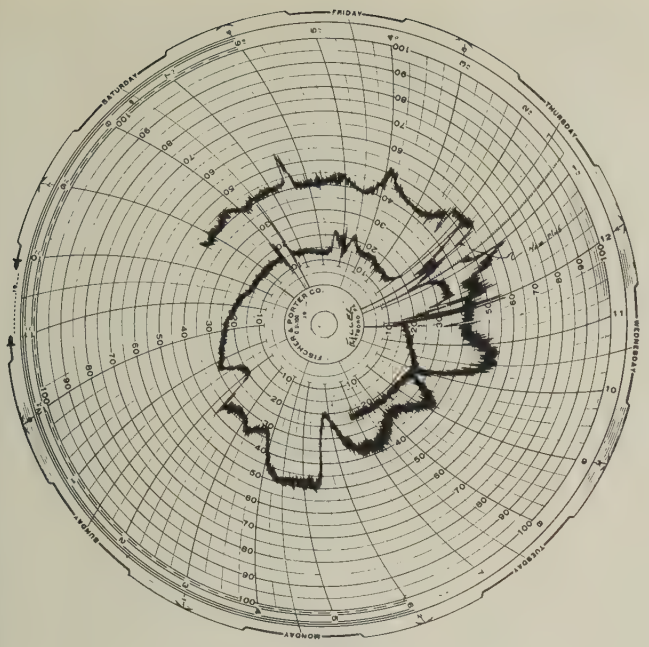


Fig. 8

curred at 5 to 10-min. intervals, and on one high-density storage tank outlet, where undiluted slugs of stock passed through the system at about 1-min. intervals, due to cave-ins in the tank. The net result in each case was ultimate impact fatigue of the lower diaphragm of the force transmitter, rendering the system dead. Ironically, control was satisfactory in each instance until the diaphragm failed.

These failures gave the necessary incentive to perfect without delay a modification already under development, whereby any force acting on the war club could be absorbed in a spring before it was imparted to the lower diaphragm of the force transmitting unit.

This change has now been successfully accomplished, together with others, which combine to effect diaphragm protection, the elimination of purge requirements, and a decrease in the low consistency control limit well below the previous 2.3%. The modifications have undergone testing under extremes of flow and consistency and are now being added to the units that previously failed, with the expectation that even these difficult applications may now be controlled.

WHAT NEXT

With convincing evidence at hand to show that the new concept in consistency regulation is entirely sound in principle, and that the means of practical application and control are embodied in the current designs, complete systems for stock handling are rapidly being built around the units, to provide more accurate blending, ratioing, refining, and weight control than has heretofore been feasible.

For the future, the shear principle will be extended to other consistency regulator configurations in order to make the benefits of this concept available to all portions of the stock flow systems throughout your mills.

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2. Head, V. P., and Durst, R. E., *Tappi:* 40, No. 12: 931–936 (Dec., 1957).

Presented at the meeting of the Kalamazoo Valley Section of TAPPI held on Kalamazoo Mich., Nov. 6, 1958.

December Meeting

Inman's Restaurant in Galesburg, Mich., was the site of the third TAPPI meeting of the Kalamazoo Valley Section, Dec. 4, 1958. This meeting was held jointly with the Michigan Division of Superintendents, and featured an afternoon workshop on "Communication Problems." This session was very ably conducted by Vernon Wanty of the Communication Department of Battle Creek Community College.

W. O. Kroeschell, program chairman, introduced Jesse Rogers, staff assistant for production planning, Champion Paper and Fibre Co., Hamilton, Ohio, who discussed "How to Make a Conference Succeed." The three types of conferences as described by Mr. Rogers are (1) the problem solving conference, (2) a decision selling conference, and (3) the informational conference.

In the first type, the leader tries to guide the group toward reaching an agreement or a suitable conclusion. The chairman of this type must be a good discussion leader and have full knowledge of the diverse personalities who make up the meeting. He must try and have the participants evaluate, analyze, and refine the best ideas so that the group can ultimately use these for reaching a conclusion.

In the decision selling conference, the chief purpose is to obtain group acceptance of a decision already made. The leader should attempt to draw out pertinent ideas and suggestions, and should leave the participants with a feeling of having shared in the decision.

The purpose of the information type conference is to pass on information. Practically all of the talking is done by the leader in this type meeting. The presentation must be clear and concise. The leader must have a complete grasp of all the material under consideration.

As a technique which might assist us in conducting more successful conferences, Mr. Rogers suggested that each participant be assigned an observer role on a rotating basis. Acting in an impartial manner, he can evaluate the actions of the leader and participants, and probably develop an entirely new perspective relative to conferences.

A color movie entitled, "Production 5118," by The Champion Paper and Fibre Co., showing the effects of industrial communication concluded the evening.

P. Dean Graham, Jr., *Secretary*

You and Your Communications

Vernon Wanty

It seems that in industry today, you have so many courses and lectures on communications that every staff member from the office boy to the company president must know all about "feedback" and communication theory. So I am going to fall back on the advice given by old Dr. Johnson, that our problem is not so much to inform people as to keep reminding them of what they already know. And I feel that for people in industry and their knowledge of communications, it isn't so much a matter of getting new knowledge, as of being reminded of what they already know.

So, let us remind ourselves of a few basic principles. First it seems that most of us are inclined to start talking before we start thinking. We would do well to think of the old carpenter who said, "To me, talkin' 's like carpenterin'; it's wise to make two measures for every saw." But we hear so many people tell us to think before we start to communicate, that like a lot of TV commercials, the advice fails to get through. As a result, we often find ourselves in embarrassing situations, which, when we review them, show plainly that we started talking before we started thinking. Lack of thought also leads us to make snap judgments abou people and situations, so that we sometimes resemble the woman in the situation created when a pilot of a light plane was forced down for lack of gas, and landed his plane on the New York Thruway. Jumping out of the plane, he ran toward a car that had pulled

Vernon Wanty, Instructor, Battle Creek Community College, Battle Creek, Mich.

Chemical Pulping Processes

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up out of his way just ahead. As he approached, thinking to beg a ride to the nearest interchange, a woman stuck her head out of the window. "We'll get out of your way, mister," she said, "Only my husband could start out on the New York Thruway, and end up in the middle of an airport."

It sounds corny, but it's still a fact that we have to examine all our communications before making them, if we want them to be successful. Take for example, a simple communication like a routine production form. Forms, numerous though they are in industry, do save time, providing they are understood by the fellah who has to fill them in. It's so easy, if you are responsible for drawing up a form or a questionnaire to jot down questions, without giving any thought as to whether the questions are easy to answer. Naturally, they're easy to you, you made them. But how about the man in the shop? Watch you don't get in the position of the junior high school teacher, who had just given out her term reports. She saw one little blonde girl scowling at her report card. "What's the matter, Dolly?" the teacher asked. "Don't you like your grades. "I certainly don't," the kid answered. "You've given me an 'F' for Sex, and I din't even know I was taking it."

You might say, "But a kid like that's kind of stupid," or maybe you think that man in the plant is stupid because he can't understand what you have written. What you know about communications and human relations tells you that this is a wrong attitude in the first place. But even if people are stupid, you have to deal with them, and just thinking about them in this way isn't going to help you to success in communicating with them.

We know we have to examine our communications for them to be successful, and not only for the way they are written, but for how they are going to affect people. One of the most frequent questions asked by all of us is, "What's in it for me?" And somehow, we have to get the answer to this question into our communications. After having done this, we have then to examine our communications for timing, the place for them to be delivered, that is whether in public or in private; and we also have to make sure that our communications do not depart too radically from what our listeners or readers have been used to.

Let us remember, too, that people often only see and hear what they want to see and hear. If I were to ask any one of you if you listen, I feel sure you would claim that you do. Here's another funny thing, it's always the other fellah who doesn't listen. But it has been proved many times that most of us fail to listen as we should. For example, if we are listening to a speaker, we don't let him get too far along before we are wondering where he bought his tie, or how much he paid for that suit. I remember shortly after I came from England some years ago, I used to do quite a bit of speaking, and often after I had given a speech, someone would come up and ask, "Did you get that suit in England?" Then I would wonder how much competition my suit had been giving me while I had been speaking. Often, too, I would be speaking, and would realize that some people were not listening to what I was saying, but merely to the accent I naturally used to say it. Let's pay more attention to our listening, especially in face-to-face situations. So many of us in conversation start to give an answer before we have heard what the other fellah's going to say, and that's a sure way to trouble.

This necessity for listening plays an especially important part, when we are trying to teach. In teaching, as most of us know, we first have to prepare the ground. Let the man know what the job is about. And it is particularly important to answer that "What's in it for me?" question. I am reminded of a story that comes from the Navy. A captain of a submarine on its trials noticed the seeming unintelligent deck-hand who was responsible for pushing the button that worked the conning-tower hatch. Thinking to impress the sailor with the importance of getting the hatch down at a given signal, the captain said to him, "You know sailor, this ship cost Uncle Sam millions of dollars, and on board we have hundreds of technicians whose training cost Uncle Sam thousands of dollars. And you are responsible for the lives of these men and for this ship." "Yes, sir," replied the lad, "And then there's me." The captain didn't worry any more. He had answered the "What's in it for me?"

And in teaching, after having prepared our man we should give him a demonstration. Show him how, not forgetting to explain the steps on the way. Some of these steps are so simple to an experienced man, that he forgets sometimes that they need to be explained. And after having done the explaining bring in the listening. Ask questions, not giving the intention that you want to test the student, so much as that you want to test whether you have gotten the knowledge across.

As most of you well know, after the demonstration comes the try-out when the student is given a chance to go it alone under supervision. This is a danger period for many people. If for example, your student happens to be your wife learning to drive, this is a good place to call another instructor. But with a normal student here is a place where you have to use patience. Remember that what is simple to you, might seem very complicated to the man you're teaching.

And last of all, don't forget to follow through. This is an important phase of all communication, and one many of us are likely to forget. We forget to get "feedback." Did we get across, or didn't we? We can't afford to leave this to chance. We need to keep going back to see how we are doing, just as we need to keep going back over what we already know. Let's remember again, Dr. Johnson. "We don't need so much to know, as to keep reminding ourselves of what we already know."

Presented at the meeting of the Kalamazoo Valley Section of TAPPI held in Galesburg, Mich., Dec. 4, 1958.

Some Aspects of the Waste Paper Situation

RALPH W. KUMLER

ACCORDING to preliminary figures, pertinent facts concerning the operation of the pulp and paper industry in the United States for 1957, are as follows:

	Million tons 1957	Million tons 1956	Per cent change
Paper and board produced	30.7	31.4	−2.3
Paper and board consumed	35.2	36.5	−3.6
Consumed by paper and board mills			
Total fibrous material	32.1	33.1	−2.9
Waste paper	8.5	8.9	−4.7
Market pulp	2.8	3.0	−8.0

	1957	1958
Total fibers from waste paper, %	26.3	26.7
Portion of total board and paper consumed reclaimed as waste paper, %	24.1	24.3

Percentage calculated on unrounded data.

The above follows a trend of waste paper consumption that has held generally since 1944, at which time waste paper constituted 36.6% of the total fibers used and 35.5% of the paper and board consumed. The high percentage of fibers from waste paper consumed in 1944 was, of course, largely a result of our war economy. The downward trend that has since prevailed was halted temporarily in 1951 as a result of the Korean War. As we recede from the influence of military hostilities there may be a lessening of the rate of decline, but more experience will be required to determine this point. There has been considerable shifting in consumption, some mills curtailing and others increasing its use.

THE FIBER SUPPLY

In looking at the future of waste paper, consideration should be given to the fiber supply picture as it now appears. The United States Forest Service published, in 1955, the Timber Resources Review. This is a thorough survey which shows what our timber resources are, where located, by whom held, its end uses and rates of growth and cutting, as of 1952. A most interesting feature of this report is the disclosure that timber growth has finally overtaken the rate of cutting and, in 1952, wood was growing approximately 1.3 times as fast as it was being harvested. Considering that in 1918 the cutting rate was more than four times growth, this is welcome news against a background of thinking on the part of many people that the forests are being rapidly depleted.

At first glance it would appear that the importance of waste paper is diminishing. However, in comparing present and past actual stands of merchantable timber, a somewhat different picture is presented. Wood growth is not the same as wood supply. An old forest may have a great deal of merchantable timber, but very little growth. On the other hand, a forest of young trees may have a high growth rate but little available timber. The cutting of an old forest tract and its replacement by young trees would result in an increased growth rating but a reduction of timber volume. The Forest Service points out the difficulty of comparing the last survey with previous ones because of improved techniques. However, their best estimates of volume of growing stock for different years follows.

An important point, brought out by the Timber Resources Review, is the fact that the increase in ratio of wood growth to cut is mostly in hardwoods. While growth of all merchantable species was 1.33 times the cut in 1952, the cut of soft woods was 1.07 times growth. We had not, at that time, yet reached a point where a surplus of long fibered woods was accumulating.

Year	Timber stand. billion cu. ft.
1930	527
1938	508
1945	490
1954	498

It is also well to consider the local situation in the northeastern quarter of the country which is the most populous and which holds the most paper and board mills. The Timber Resources Review divides the United States into three major regions, North, South and West. The area designated North extends from the Atlantic Seaboard north of Virginia to the Great Plains, but dips southward at the westward end to include western Texas and western Oklahoma. In 1952, the year on which the Timber Resources Review is based, this area produced more than half of the total paper and board. It held 65% of the population, but had only 44% of the total wood growth in the United States of America. It produced 53% of the hardwood growth but only 12% of the long-fibered softwoods. This area must, therefore, use considerable waste paper or pay heavy transportation charges for pulp coming from distant points. It is logical to have distribution of paper and board manufacturing facilities correspond to the distribution of population, but this is feasible only to the extent that waste paper is used as a major raw material in those areas which are short of wood of required species.

Let us consider a board mill located near a large metropolitan center. It may ship its product into the city and bring back a truckload of waste. Neglecting for the moment the difference between waste paper and pulp prices, it costs something like $16.00 per ton to bring pulp from the deep South to the North by rail. The cost of trucking from a metropolitan center to a suburban paper mill is on the order of $3.00 per ton.

A discussion of the over-all cost of waste paper versus wood pulp would be rather complex and beyond the scope of this paper. The cost differential varies according to the grade of waste paper being used. Because of lack of statistics it is impossible to arrive at an aggregate saving to the paperboard industry resulting from the use of waste paper versus virgin pulp. Certainly, the saving is great, comparing the cost of pulp with the bulk grades of waste paper.

THE PROBLEMS

Assuming that waste paper contains desirable fibers, the one big obstacle to the expansion in consumption is foreign materials. Much of this comes from substances intentionally applied to paper and board to enable it to perform its various functions. Paper is not naturally adhesive (which is fortunate), so adhesives must be supplied. It lacks complete imperviousness so it is combined with plastic films, metal foils and asphalt to achieve this property. Indeed the market for paper would be very limited were not such additive materials available.

However, when collecting waste paper these nonfibrous additives create problems. What can be done about them? Of course, much of it is taken care of in the ordinary business transactions. Generally packers and dealers are aware of mill requirements and strive to deliver waste paper free of unwanted substances. The Waste Paper Institute has taken a step forward in this direction by adopting WP-54, which sets forth specifications for various paper grades and outlines what constitutes good trade practice. But the number of troublesome items has been multiplying and mills, faced with demand for higher and higher quality products, have been compelled to be more critical of waste paper quality. Some materials, such as rubber-based

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adhesives, are destructive in such minute amounts as to escape detection in careful sorting operations.

The logical course to take is to follow the waste paper and the troublesome materials to their sources and to secure all possible remedies at these sources. This is one of the principal tasks that the Waste Paper Utilization Council has assigned itself.

There are two general avenues of approach that can be taken in solving these problems. First, is an appeal to those who supply paper additives, such as adhesives, coatings, plastic films, metal foils, inks, and the like. Such manufacturers should be made aware of the effects of their products on waste paper reclamation. Naturally, they will produce and sell what their customers demand and the effect on waste paper receives secondary consideration. Most of the producers of paper additives have been most sympathetic when presented with the problems of waste paper. Some have consulted the Waste Paper Utilization Council before placing new items on the market. In general, however, the decision regarding the use of a product rests with the buyer who is usually the generator of waste paper.

This brings us to the second branch of industry that can be effectively approached, namely, the paper convertor, the term being applied in its broadest sense. This is the concern that normally buys both the paper and the additive and generates the waste paper. It is he who must demand products that are acceptable in waste paper, or at least indicate a preference for them. When this happens, the supplier of the additive exercises his ingenuity to develop products with which the waste paper user can live.

In many cases it has, so far, not been possible to prepare additives that perform the necessary functions and, at the same time, permit easy reclamation of waste paper fibers. In such cases the waste paper generator is requested to withhold the objectionable materials from his waste paper stocks. He knows the nature of the materials he handles and with just a little effort can be aware of their effect on waste paper value. With a little organization in the plant, such materials can be relegated to the trash can at little or no cost. This requires planning, starting with the entry of material into the plant and continuing until the waste paper leaves.

There are also steps that the paper or board mill can take to help the situation. It can be sure that materials acceptable in waste paper are used whenever possible on the products they sell. Water-soluble, pressure-sensitive splicing tapes are available for lap splices and a type satisfactory for butt splices will be at hand if there is demand for it. Wet-strength paper can be tagged. It is not a problem if segregated and identified.

Mill Processing

The problems of waste paper must be attacked on all fronts, which includes mill processing of waste papers. Progress has been made in this direction. Screens and screening methods have been improved and the development of centrifugal cleaners has helped tremendously. The latest development is the pressure extractor, which removes nearly all of the rubbery adhesives, tarry and soft ink materials that have escaped sorting and other cleaning processes. However, even though equipment and processes are developed to handle any kind of extraneous material, the need for segregation will still exist. Certainly a bale of waste paper can be more economically processed if its contents are known. If substances requiring special handling must be present, it is better that materials of widely diverse nature not be included in the same bale or even in the same shipment. In the foreseeable future there will be a need for careful control of the product entering the mill.

THE WASTE PAPER UTILIZATION COUNCIL

The Waste Paper Utilization Council was established at the beginning of 1953 to tackle the problems of reuse of paper and board and to take steps that companies could not well carry out individually. It was felt that concerted action would be more forceful. The establishment of a climate conducive to the production of satisfactory waste paper means the dissemination of technical knowledge on a broad front. Information conveyed in connection with the negotiation of a business deal may not be taken as seriously as if it comes from a central authoritative source that has no direct interest in individual trading.

A study of a new additive which adversely affects the value of waste paper may reveal that the objectionable features can be eliminated without losing the functional properties. An instance of this is the synthetic adhesives used in book and magazine binding which were at first ruinous to waste paper, but which now present scarcely any problems, at least to deinking mills. The demand for acceptable products has stimulated the development of totally new materials, such as water-soluble, pressure-sensitive roll splicing tapes and alkali-dispersible flying splice adhesives. Nonasphaltic box tapes have been developed in response to demand and further improvements in this field may be expected.

Because of the large number of generators of waste paper, the approach to them has been necessarily quite general. It has taken the form of direct mailings, consisting of bulletins directed to management, suggesting means of making waste paper more valuable. Because much depends on the care taken by employees, these bulletins have been supplemented by posters to be displayed on bulletin boards designed to convey in few words what is required in waste paper stocks. There is no good yardstick by which to measure the effect of this program. However, if inquiries and communications to the Council office may serve as a criterion, manufacturers of additives and generators of waste paper are giving more thought to the effect of their products and practices on waste paper values than heretofore.

THE ADVANTAGES OF THE USE OF WASTE PAPER

Perhaps one reason why waste paper consumption is not higher than it is, is a lack of appreciation of its valuable attributes. Clouse (*1*) has pointed out the plus value in deinked waste paper pulp. Some of the items, at least, are applicable to the use of waste paper in board mills. Waste paper has the following advantages:

1. It is low in cost.
2. It has a high degree of opacity.
3. Little or no beating is required.
4. Fibers are already blended to suit many furnishes.
5. Brightness can be better controlled than with virgin pulp.

Other items that seem to be valid, but are debatable:

6. Better bonding—less fuzz.
7. Less moisture sensitivity.
8. Less tendency of finished paper to curl.

Another important feature that should be emphasized is availability. Less than a quarter of the paper and board consumed is returned for reuse at present. If waste paper were collected today at the same rate as in 1944 (35.5%), the supply would be nearly 50% greater. It is comforting to know that we have this tremendous reservoir of raw material that can be drawn on in time of need. It must be borne in mind, however, that the flow of waste paper cannot be easily turned on and off like tap water. Additional supplies mean new sources from which collection may cost more. As pointed out above, generators of waste paper require some indoctrination which may take a little time. Mills must be prepared to cope with errors that may occur, in the meantime.

COOPERATION NEEDED

It is difficult to conceive of a situation that calls for more

understanding and cooperation. Here is a raw material that can have great or little value, depending on the thought and intelligence given to its preparation for market. It is not possible to estimate the cost of rejections, discarded paper stock and increases in mill production costs due to paper stock contamination, but obviously the figure is a large one. This could be added to profits all along the line if each did his part.

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Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

Kamyr Digester on Southern Pine

CARROLL D. OWENSBY and
HENRY P. HALSELL

THE Kamyr continuous digester is one of the interesting features of the new pulp mill of Gulf States Paper Corp. at Demopolis, Ala. Operation began in August, 1957, with the production of unbleached pulp at a 150-ton-per-day rate. The performance data to be presented have been collected during the ensuing months as production has increased to design capacity.

The digester was designed to produce 300 tons airdry pulp per day using one operator per shift, whose duties also include routine maintenance, lubrication, logging data, and housekeeping.

PROCESS DESCRIPTION

A diagram of the installation is shown in Fig. 1. Chips are metered, A, into the low-pressure feeder, B, which consists of a rotating tapered plug with pockets, adjusted for minimum clearance with the housing. The low-pressure feeder serves as a vapor lock ahead of the steaming vessel, C, where steam at 13 to 25 p.s.i. drives out inert gases and blanches the chips. The chips are conveyed through the steaming vessel with a large screw, being retained about 5 min. and discharged into the digester high-pressure feeder, D. The steaming vessel is designed to use steam from the blow tank, E, excess being relieved to the turpentine condenser. Digester gases are also vented through the steaming vessel and thence to turpentine recovery.

The digester high-pressure chip feeder, D, is the heart of the system and, like the low-pressure feeder, consists of a rotating tapered plug, but with ports extending through the plug instead of pockets. As the plug turns, chips are sluiced into the vertical port with circulating liquor and retained in the port by a screen on the lower side of the housing; then in the horizontal position they are conveyed to the top of the digester with high-pressure circulating liquor. The feeder plug contains four separate ports at 45° angles, so arranged that the vertical and horizontal flows are simultaneous but separate. Since the ports are overlapping, the flow is continuous in both directions as the feeder turns.

Chips and liquor enter the digester through the top separator consisting of a short tubular screen surrounding an auger which wipes it clean. The screened liquor recirculates to the high-pressure feeder through a pump and the chips move down through the body of the digester. The unit at Demopolis to 80 ft. long with a diameter of 13 ft. The digester operates full of liquor, a small amount of gases being vented periodically to the steaming vessel as mentioned. The chip level is sensed by two spaced rotating paddles and transmitted to lights on the control panel.

Cooking liquor together with some black liquor enters the top of the digester through a two-stage centrifugal pump, F, which maintains the digester pressure of 165 p.s.i. At this pressure, vaporization in the system is avoided. The upper section of the digester serves as a soaking zone. As the chips move downward they pass by a series of circumferential screen plates through which the cooking liquor is removed and recirculated through indirect steam heaters, G. Two rows of screen plates are used alternately on a time cycle to prevent plugging. The chips are heated in the upper circulation zone and cooking starts at the following circulation zone. Cooking proceeds until the mass reaches the bottom, where black liquor for dilution is introduced just above the bottom scrapper. Retention in the digester is about $2^3/_4$ hr. at designed capacity, but varies with production rate and these variations are compensated for by adjusting other variables as discussed later. For example, at low production rates chip and liquor flows are reduced, requiring reduced discharge rates to maintain the chip level in the digester, resulting in increased retention times. The pulp leaves the bottom through a ball valve and enters a special strainer, H, where some black liquor is removed to control the discharge consistency, and this liquor is recirculated to the bottom of the digester for dilution as mentioned above, the pulp being released to the blow tank through a selective orifice plate and by means of the speed-controlled sluicing device, I. The sluice is essentially a pressure-lock chamber with a poppet valve at each end, stock alternately fills from the pressure side and flashes out to the blow tank as controlled by timing the operation of the valves.

The installation at Demopolis uses a dual feed system, comprising two steaming vessels and associated low and high pressure feeders, permitting a wide range of capacity and flexibility. A spare heater, which can be switched to either upper or lower heated circulation zone, has been installed to permit cleaning of heater tubes without interrupting operation. A spare compression liquor pump has also been similarly installed since the pump is of a special Kamyr design made only in Sweden. The equipment is not enclosed, excepting the control room at the third floor level.

The operation is controlled and checked with extensive instrumentation. The flow of chips to the chip bin is regulated by positioning the plows on the turntable at the chip silos and checked by the conveyor weightometer and integrator, and the level in the chip bin is indicated by lights on the control panel. The chip feeder is adjustable and the rotary speed is recorded. White and black liquor feeds and liquid circulation flows and temperatures are indicated, recorded, and controlled.

Most motor loads are indicated by ammeters on the control board, many with green and red lines indicating normal and maximum loads, respectively, which are useful in spotting abnormal conditions. For example, one time when the digester chip level lights failed to operate, chip level was temporarily indicated by the ammeter measuring the load on the top separator auger as it pressed against the chips.

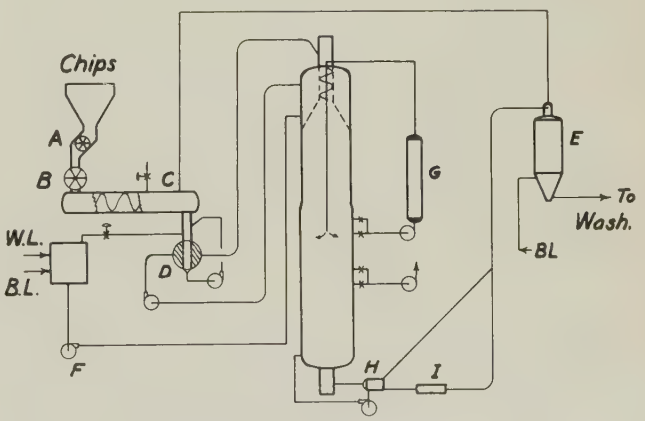

Fig. 1. Kamyr continuous digester system

CARROLL D. OWENSBY, Process Evaluation Engineer, and Henry P. HALSELL Resident Manager, Gulf States Paper Corp., Demopolis, Ala.

Heaters are equipped with pressure-drop recorders and condensate conductivity cells as well as the usual temperature recorders. Various other flow and level instruments are used to control and indicate operation. Because a small blow tank is used, pulp is sampled periodically for testing from the third brown stock washer.

START-UP EXPERIENCES

A few weeks before starting up, mill personnel were given intensive training in operation, maintenance and safety by classroom lectures and by mill tours, where they could examine actual equipment. As construction was completed, they made "dummy" runs and were drilled in emergency procedures for utility failures. A synthetic white liquor was made up to match that expected from normal operation, and black liquor was shipped in from the company's nearby mill at Tuscaloosa.

For the start-up of the digester, it was necessary to make a batch cook of the initial charge of chips before feeding and blowing continuously. Thereafter, except for internal inspection, the digester was shut down fully charged by lowering temperatures and started again after bringing them back to normal. Kamyr representatives were present to assist in initial operations and training of operators.

Since a considerable portion of auxillaries and piping is under high pressure, some under pulsating flows, gasket failures were frequent during start-up, but largely eliminated after improving on some of the flanged joints. One gasket failure at the digester necessitated emptying it through the normal blow line for repairs. Some motor failures were experienced from rain and liquor spills; and expected, but annoying, minor start-up troubles were encountered, such as water in instrument air lines, utility interruptions, tramp iron, etc. As there is no storage between the blow tank and the washers, other than that of approximately 30 min. in the blow tank itself, some shutdowns with full digester were caused by interruptions outside the digester area.

Relatively smooth and continuous operation has been obtained since the first part of October. Because retention time in the digester was about 6 hr. at the initial production rate, changes in process control variables were reflected only after that time had elapsed, and there was a tendency at first to overcontrol. Practically, only two variables, temperature and white liquor feed, are used to control at any given production (chip feed) rate. Both these variables are held uniform at any set point by automatic controls. White liquor is drawn from isolated storage tanks, each having a capacity of 250,000 gal., the flow rate being adjusted for strength when tanks are changed.

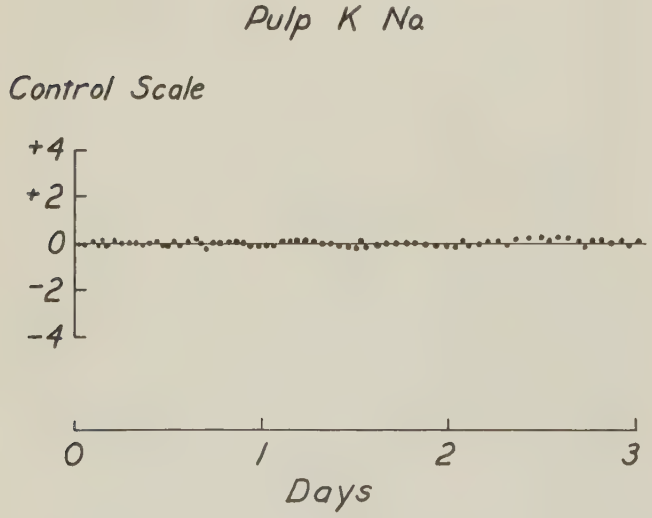

Fig. 2

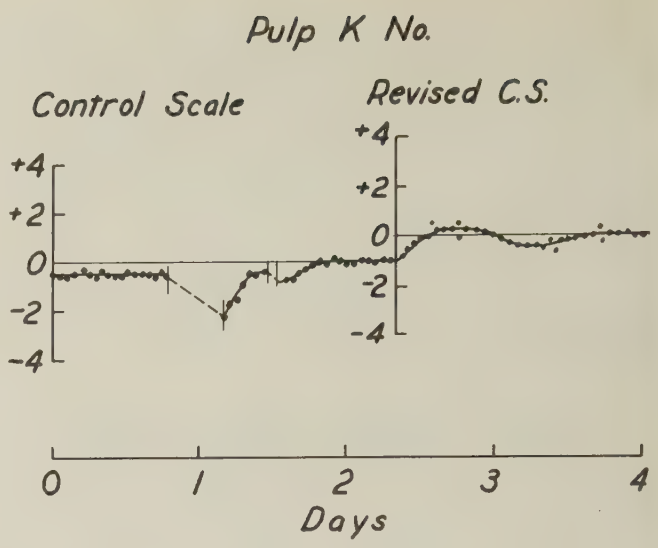

Fig. 3

Operating temperature ranges have been somewhat limited by the characteristics of the high-pressure feeder and the outlet device, although sufficient latitude is permitted for either hard or soft cooking. Temperature extremes aggravate steam hammer in the piping, but usually are encountered only on starting up.

It was found that when the system was shut down unexpectedly for several hours, and started up by bringing the circulating liquor temperatures up to normal again at reduced flow rates, a softer stock resulted until equilibrium was reestablished. This might be expected since circulation was stopped and temperatures within the insulated digester fell slowly, resulting in increased retention times in the cooking zone. When shutdowns are anticipated, circulating liquor temperatures are reduced beforehand, counteracting this action.

Initial operation has been with loblolly pine chips of a size common in the southeast industry. The ratio of cooking liquor to wood ranges from 0.145 to 0.16 lb. active alkali per pound moisture-free wood for most cooking conditions, and the total liquid to wood ratio within the digester is about 2.5 lb. of liquid per lb. of moisture-free chips. This has resulted in good washing with conventional three-stage rotary washers without the use of foam killer. The total solids strength of the final black liquor is conventional.

The temperature of the liquor conveying chips to the digester is about 220°F., which must be kept low enough to avoid flashing back into the steaming vessel as the high-pressure feeder turns. The chips are heated to about 300°F. in the upper circulation zone and to about 338°F. in the lower (cooking) zone, depending upon production rate and the degree of cooling required. The bottom circulation temperature usually runs a few degrees hotter than the cooking circulation temperature, apparently because of the heat of reaction, and must be maintained above a minimum point, below which hammering occurs in the outlet sluicing device.

RESULTS OF OPERATION

Uniformity of product quality has more than fulfilled our expectations. An example of uniformity of product quality is shown in Fig. 2. The established control scale, measured by the TAPPI pulp permanganate number, is plotted against time. In Fig. 3, an earlier run, two unexpected shutdowns occurred, and later the control point was changed and achieved by adjusting temperatures and chemical feed rates, although with some degree of overcontrol. The pulp produced has been as strong or stronger in burst, tear, and fold as that of other manufacturers in the southeast.

Another advantage of the continuous digester is uniform

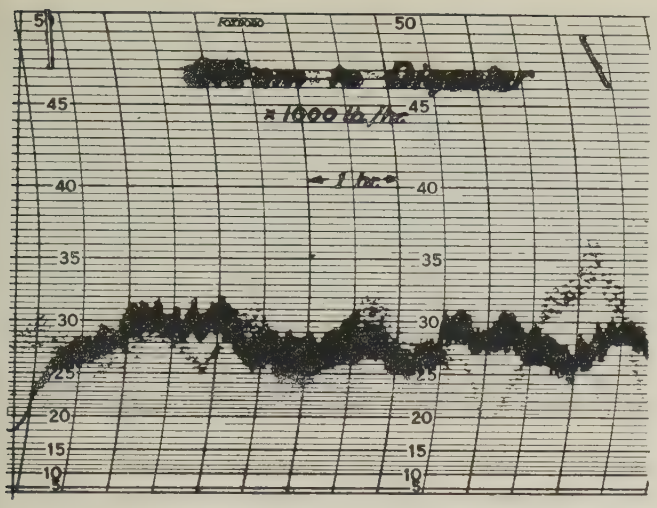

Fig. 4

steam requirement. A typical section of the steam flow strip chart is shown in Fig. 4. A similar chart at the steam boilers exhibits an absence of the peaks which are characteristic of batch digesters.

Knots in the pulp have been very low, and rejects from the flat screens have averaged less than one per cent. Bleaching operations have been simplified by pulp uniformity, permitting closer control of bleached product. Recent operation has been close to the designed capacity of the unit, and performance has been smooth and satisfactory.

Production rate changes are accompanied by corresponding changes in cooking temperature and active alkali/wood ratios to achieve the same degree of digestion, since the retention time of the chips in each zone is changed. Anticipated shutdowns are prepared for by lowering the cooking temperature about 1 hr. in advance, as mentioned above. Turpentine recovery has been postponed for the present pending some piping revisions.

So far, the digester has been used to make stock for unbleached, semibleached, and high-brightness full bleached kraft pulp from southern pine.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

A Ground Water Survey

RICHARD A. DANDO

In 1955, the St. Regis Paper Co. mill at Jacksonville, Fla. required additional raw water capacity in order to expand the pulp and papermaking facilities from 350 to approximately 1300 tons per day. The mill is located on the St. John's River, between two tributary streams, all of which contain backish water. Thus, no surface water supply suitable for process water was available.

The existing facilities for process water supply consisted of two 20-in. limestone wells, having a combined maximum capacity of 8000 g.p.m. These wells are located on company property, and spaced 1800 ft. apart. To drill sufficient numbers of wells at this spacing and yield to supply the increased demand would have required expansion of company property. To evaluate the problem, the firm of Leggette, Brashears & Graham, ground water consultants, was retained.

The well drilling completion reports indicated that the first two wells (nos. 1 and 3) were 1380 and 1350 ft. deep, respectively, and that each well had an artesian flow of about 3000 g.p.m. when drilled in 1951. In 1955, the pumping level in these wells, when operated simultaneously at maximum capacity, was about 50 ft. below the land surface.

The principal source of ground water in the Jacksonville area in a series of highly permeable limestones which lie at depths of 580 or more feet below the land surface. None of the water wells is known to penetrate the rocks below the lower formation at 1400 or 1500 ft.

The limestones that produce water in the area lie at or near the land surface in the western part of North Central Florida. From this outcrop area, the limestones dip gently to the northeast, beneath imbedded layers of sand, clay, marl, and limestone. Along the northeast coast of Florida, parts of this upper formation are relatively impermeable and act as a confining layer that prevents upward flow of artesian water from the underlying limestones, and downward flow of salt water from coastal bodies of sea water.

In the Jacksonville area, some wells were known to have a very high capacity. If this high capacity zone was present beneath the mill area, the number of wells and the spacing between them could be reduced.

Drilling of the first additional 20-in. production well (no. 5) was started in December, 1955. It was recommended that this well be drilled to a depth of about 1400 ft. However, the drilling company suspended drilling at 1260 ft.

When completed, the artesian flow of the well was about 2500 g.p.m. while nos. 1 and 3 together pumped about 7500 g.p.m.

In January, 1956, well no. 5 was test pumped several times at rates ranging from 2500 to 5500 g.p.m. The pumping water level was about 22 ft. below land surface when pumped at the rate of 3600 g.p.m. and about 80 ft. below land surface when pumped at the rate of 5500 g.p.m.

The decline of artesian pressure produced when well no. 5 was test pumped was measured at several observation wells located from about 700 to about 5000 ft. from the pumping well. Artesian pressures stopped declining about 10 hr. after the start of each pumping test, indicating that sufficient ground water had been intercepted to maintain a constant yield at well no. 5. Calculations based on the test measurements indicated that an additional 18,000 g.p.m. could be pumped from five wells spaced 1000 ft. apart without causing an excessive decline of water level in well nos. 1 and 3. The test data indicated that the average pumping water level in the five wells, when simultaneously pumped at the rate of 3500 g.p.m. each, would be about 50 ft. below land surface. It was decided, therefore, to drill four additional wells at site nos. 4, 7, 8, and 9 and to reserve site nos. 2 and 6 for future use.

Drilling of well no. 7 was started in March, 1956. The drilling company was instructed to drill the well to a depth of 1400 ft. so as to determine the yield of the limestone from 1260 to 1400 ft. which contributes part of the water produced by well nos. 1 and 3. The measured artesian flow of well no. 7 was 3485 g.p.m. when the depth was 1270 ft., and 7950 g.p.m. when the depth was 1400 ft., most of the additional flow being derived from the limestone beds from 1280 to 1300 ft. Tests at well no. 7 showed that when the artesian flow rate was 4400 g.p.m., the artesian pressure (flowing water level) in well no. 7 was about 25 ft. above land surface. When flowing at 7950 g.p.m., the artesian pressure was about 10 ft. above land surface.

The artesian rate of flow of well nos. 8 and 9, both of which were drilled to 1400 ft., was about the same as that of well no. 7. Well no. 8 yielded 7450 g.p.m. with a flowing water level about 9 ft. above land surface, and well no. 9 yielded 7650 g.p.m. with a flowing water level about 9 ft. above land surface.

The decline of artesian pressure produced during the flow tests at well nos. 7, 8, and 9 was measured at several observation wells located from 1000 to 4000 ft. from the well being tested. The average decline of artesian pressure at a distance of 1000 ft. was about 0.5 ft., or about 5% of the drawdown

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produced at a similar distance during the pumping test at well no. 5.

The data obtained from the tests at well nos. 7, 8, and 9 indicated that five 1400-ft. wells at the Jacksonville Mill would yield 25 million g.p.d. be artesian flow with an average flowing water level of about 20 ft. above land surface.

During drilling the new production wells a zone in the lower limestone formation was encountered that produced a far greater flow of water than that yielded by any other wells in this area. In each of the new production wells, most of the artesian flow issues from a horizon of very hard, brown, dolomitized limestone having large fissures or solution channels. At the mill location, this dolomitic zone was about 50 ft. thick and was encountered between depths of from 1250 to 1400 ft. The dolomite is nearest the land surface in the middle of the well field and dips down both to the north and south. Well nos. 1 and 3 (the original production wells) were not drilled deep enough to penetrate this highly productive dolomitic zone. Not only does this highly permeable zone increase the maximum yield of the wells which penetrate it, but it reduces the interference between wells. Therefore, wells producing from this zone can be spaced relatively close to one another without large losses in individual yields due to interference.

Data obtained during the tests at well nos. 7, 8, and 9 show that the artesian pressure in the vicinity of each of the flowing wells essentially stopped declining about 10 hr. after the start of the tests. Therefore, five 1400-ft. wells should furnish a dependable supply of at least 25 million g.p.d. by artesian flow, even if several large neighboring sites were developed in the future.

Flow tests were made in August and September, 1956 by increasing the ground water withdrawal about 20 million g.p.d. Water levels in the test wells declined a small amount for about 1 day and then apparently stabilized. The results of other flow tests showed comparable periods of stabilization. Thus, it was concluded that the Jacksonville mill probably can pump 35 million g.p.d. without adversely affecting water levels in the area.

Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

The author wishes to express his appreciation to M. L. Brashears, of Leggette, Brashears & Graham for furnishing copies of consulting reports.

Use of the Asphalt Dispersion System on Waste Paper

J. J. HIGGINS

Asphalt dispersion systems were used to process over a million tons of paperboard in 1957. The largest percentage of this tonnage was in liner board; however, there has been an increased application in the folding boxboard field. Without such systems much of this tonnage would not have met the appearance quality standards required in today's market. In addition, it offers considerable savings in the cost of the board furnish because it enables the board mill to utilize a lower cost raw material.

The asphalt dispersion system, as we know it today, is a result of the efforts and research work of The Jute Research Group. The principal efforts of this group has been in research involving the utilization of waste corrugated board. The organization was conceived in 1946 when a group of 18 paper board manufacturers joined together in a common program to improve the quality of jute liner. Cleanliness, appearance, and strength were the prime considerations. This same group is now known as the Fibre Conservation Corp.

J. J. Higgins, Ohio Boxboard Co., Rittman, Ohio.

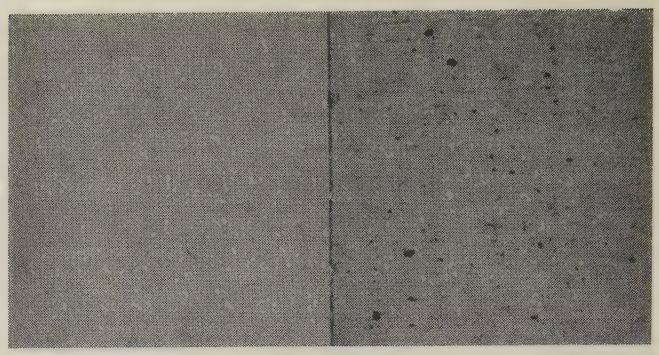

Fig. 1. Samples of heated dispersed and undispersed board

Asphalt or other thermoplastic materials in waste paper are particularly troublesome in the manufacture of liner board, therefore, elimination of these objectionable bleed spots in the finished liner was the first project actively pursued. Solvent extraction and emulsification were investigated but the cost of solvent, cost of operation and equipment were so great as to make such a process not practical. Furthermore, fire hazards associated with solvents made such a system objectionable in most plants. The use of absorptive material, such as diatomaceous earth and clay, was evaluated. The procedure only met with limited success.

After studying and discarding these methods, the principle of asphalt dispersion was considered and finally worked out in detail. The asphalt dispersion system, as finally adopted and patented, processes stock containing asphalt or waxy materials in such a manner that the thermoplastic materials are reduced in size (approximately 20 mu or less) and distributed throughout the sheet so that they are essentially invisible to the naked eye.

Figure 1 illustrates the degree of improvement that can be expected by use of the asphalt dispersion system. Both samples shown have the same asphalt content and have been heated on a hot plate to bring out the bleed spots. This is more severe than occurs even during corrugating; however, it points out the fact that once the asphalt is dispersed it will not agglomerate and cause unsightly spots.

Asphalt dispersion can be accomplished with a number of different pieces of equipment but the principle is the same. Figure 2 illustrates where an asphalt dispersion unit would fit in a typical beater room. Paper stock, after being disintegrated and cleaned, is adjusted to a consistency between 6 and 50%. It is then heated to a temperature between 200

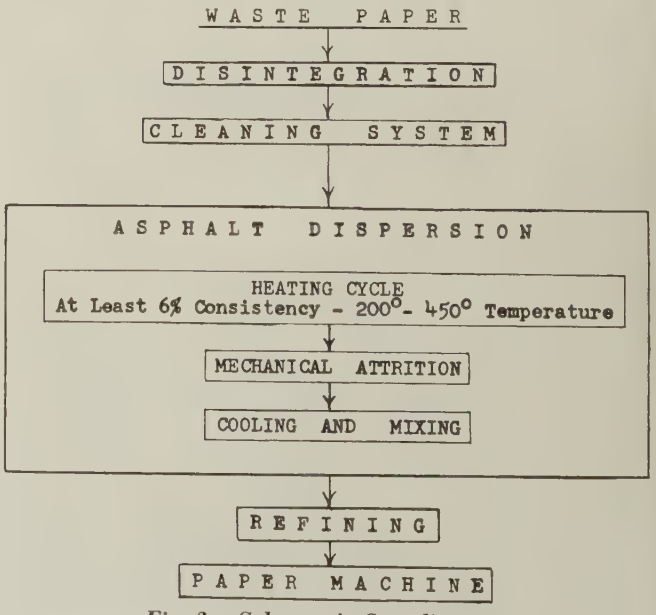

Fig. 2. Schematic flow diagram

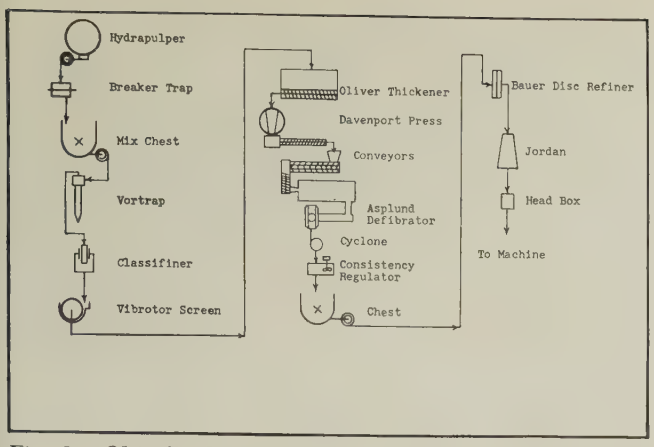

Fig. 3. Ohio Boxboard Co. no. 3 machine top liner stock preparation system

and 450°F. at which temperature the thermoplastic materials are softened and become fluid. The heated stock is then worked mechanically in such a manner as to provide attrition which will spread out the softened, fluid materials into a thin film or minute particles. The stock temperature and pressure is then reduced to maintain the dispersion and prevent the reagglomerization of the thermoplastic materials. Normal agitation occurring in stock chests is sufficient to distribute any localized heavy concentrations of the dispersed material. For best results, it has been found that sufficient water should be present during attrition to permit the thermoplastic materials to flow into the thin films or minute particles required to obtain asphalt specks virtually invisible to the naked eye. The stock is then refined by standard equipment before it goes to the machine.

With regard to the operating data, this varies considerably with the various installations. An asphalt dispersion unit required between 1000 and 2000 sq. ft. of floor space. Cost of installation is difficult to estimate since most installations included other pieces of cleaning and refining equipment. However, the basic unit will probably vary between $125,000 and $175,000. The steam requirements range from 1500 to 2000 lb. per ton with a power consumption of 2.5 to 4.0 hp.-days per ton. With regard to operating personnel, some mills have added men, others have reduced the beater room crew size.

The asphalt dispersion systems in operation at the Ohio Boxboard Co. are typical of the 30 or more now in use. Figure 3 is a flow diagram of the top liner stock preparation system of the 3 machine. After the usual defibering and cleaning operations, the consistency is raised in a vacuum thickener from 1 to 15% and then to about 30% in a dewatering press. The stock at 30% consistency is then transported by a screw conveyor to the inlet of a pressure chamber in which the stock is heated with steam to about 300°F., requiring a pressure of approximately 60 p.s.i. Compressed stock in a plug forming section at the entrance to the heating chamber maintains a pressure seal within the chamber. The stock is then mechanically worked in a disk-type refiner and the stock is blown through an orifice into a cyclone where the pressure is reduced to atmospheric. This step has a chilling effect which fixes the particle size of the dispersed material. The stock then drops into a chest where the consistency is regulated at approximately 6%. The stock is refined through a disk refiner and a jordan before it passes to the machine. Figure 4 is a photograph of the Ohio Boxboard asphalt dispersion unit, taken during installation, illustrating the control panel, conveyors, and asplund defibrator. With this process we are able to obtain a stock, which when made into paper, completely eliminates the objectionable bleeding due to asphalt present in the paper.

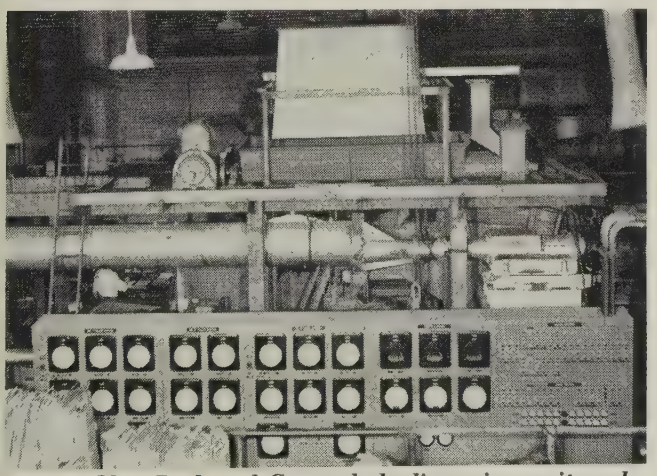

Fig. 4 Ohio Boxboard Co. asphalt dispersion unit under construction

The asphalt dispersion process is presently covered by a patent which was issued in 1954. The Fibre Conservation Corp. has licensed this patent to a number of companies on a reasonable continuing royalty basis. If there is any interest in obtaining more details about this process, the information can be obtained from the Fibre Conservation Corp., 230 N. Michigan Ave., Chicago, Ill.

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Low Molecular Weight Polyethylene—Wax Coatings for Corrugated Board

R. ROSENBAUM and E. A. SLOSS

Paper converters have employed low percentages of polyethylenes as wax additives for over 10 years for such items as breadwrappers. The reasons for using these polymers have been reported by Patton (*1*) and Vaurio and Howells (*2*). Until the advent of the low molecular weight polyethylenes, the corrugated board industry has been, in general, unable to take advantage of polyethylenes. Good scuff resistance is mandatory in most corrugated applications and the waxer cannot handle the percentages of medium molecular weight polymer necessary to impart this property.

POLYETHYLENES

It should be realized that the word polyethylene now denotes a whole family of polymers differing widely in molecular weights, viscosities, densities, and other properties. We define the low molecular weight polyethylenes to have a molecular weight of under 6000. The polyethylenes used in our experiments had molecular weights of 1500 and 2000 with specific gravities of 0.91 and 0.92.

Properties of Various Molecular Weight Hydrocarbons. Although there are tremendous differences in viscosity between the low and high molecular weight polyethylenes, such important properties as melting point and hardness are fairly close as shown in Table I.

Viscosity. The major limiting factor in handling polyethylene-wax blends is viscosity. A typical waxer can handle coating viscosities up to about 100 cp. without alterations. Viscosity at 230°F. of the A-C Polyethylene 6 in a typical paraffin and microcrystalline wax is shown in Fig. 1. Viscosities were determined with a Brookfield viscometer. About 75% of the polyethylene can be added to paraffin and still remain below 100 cp. The lower viscosity A-C Polyethylene 617 can be run as a 100% coating and still remain below 100

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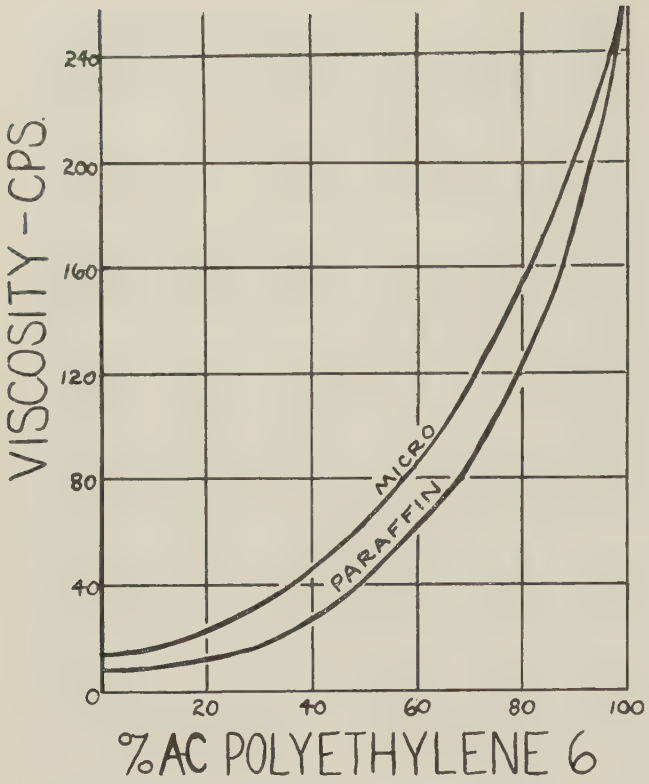

Fig. 1. Viscosity of A-C Polyethylene 6 in wax

cp. For comparison, 6% of a 21,000 molecular weight polyethylene raises the viscosity of paraffin to 100 cp.

Softening Point. The ball and shouldered ring softening point was run according to ASTM E 28–51 T and the low molecular weight polymers raised this value (Table II). Most coatings are run at temperatures from 20 to 100°F. above the melting point. The exact temperature would depend upon the equipment, speed, raw stock, coating weight, and type of finish desired. Waxing should be done at the lowest possible temperature to minimize oxidation of the coating and embrittlement of the paper due to moisture loss.

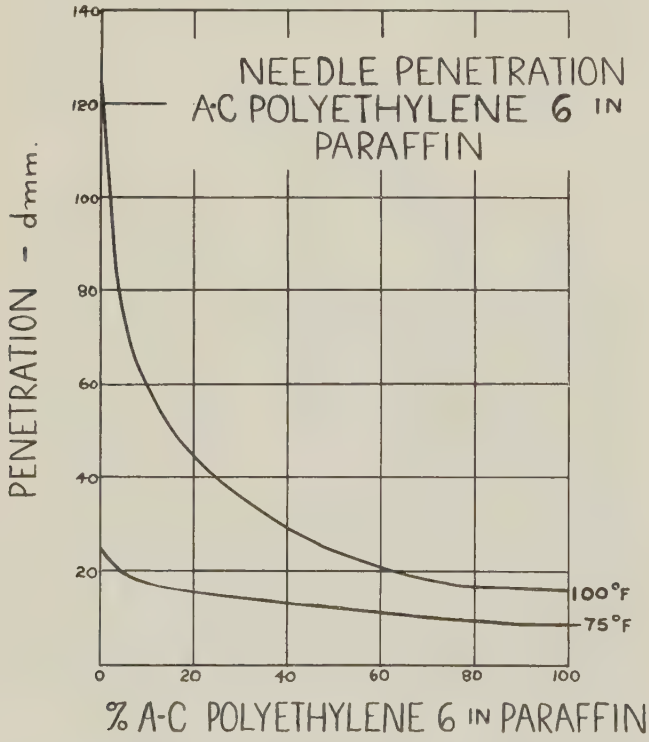

Fig. 2. Needle penetration of A-C Polyethylene 6 in paraffin

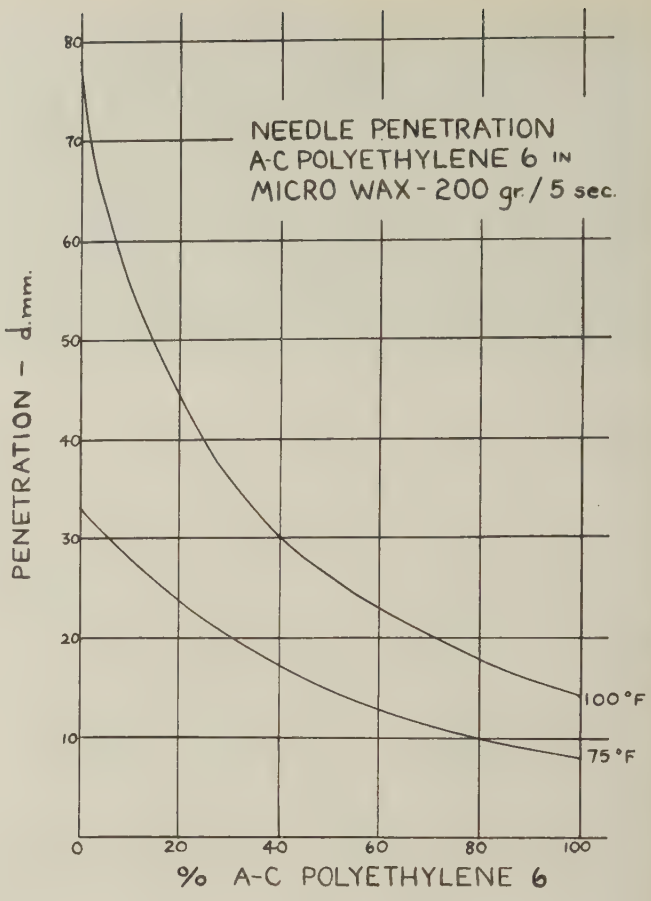

Fig. 3. Needle penetration of A-C Polyethylene 6 in micro wax

Hardness. Needle penetration (TAPPI Standard T639 sm-55) was run to determine increases in hardness. A 200-g. load was used instead of the usual 100 g. because of hardness of the polyethylene. Test temperatures of 75 and 100°F. were used. A-C Polyethylene 6 was especially effective in increasing hardness of paraffin at higher temperatures as shown in Fig. 2. At 100°F., 2% polyethylene reduced the needle penetration by about 50%. The same general trend exists with the microcrystalline wax but to a lesser degree (Fig. 3).

Blocking Point. The blocking point of waxes as measured by TAPPI Standard T652 sm-57 is raised by the addition of polyethylene (Fig. 4). The low and high molecular weight polymers are about equally effective in this respect. About 5% polymer is sufficient to eliminate any danger of blocking under temperatures normally encountered in this country.

Scuff Resistance. The chief reason for adding polyethylene to corrugated board coatings for most applications has been the need for improved scuff resistance. Unfortunately, there is no standard TAPPI method for measuring this property of

Table I. Comparison of Polyethylenes and Paraffin

	Molecular weight	*Viscosity, cp., at 284°F.*	*Melting point, °F.*	*Hardness 200G/77F/5 sec.*
Paraffin	360	2	134	25
ACP-617	1,500	100	192	16
ACP-6	2,000	180	212	4
ACP-615	5,000	4,000	218	3.5
Medium molecular weight polyethylene	12,000	110,000	230	3.5
High molecular weight polyethylene	21,000	63,000,000	230	3

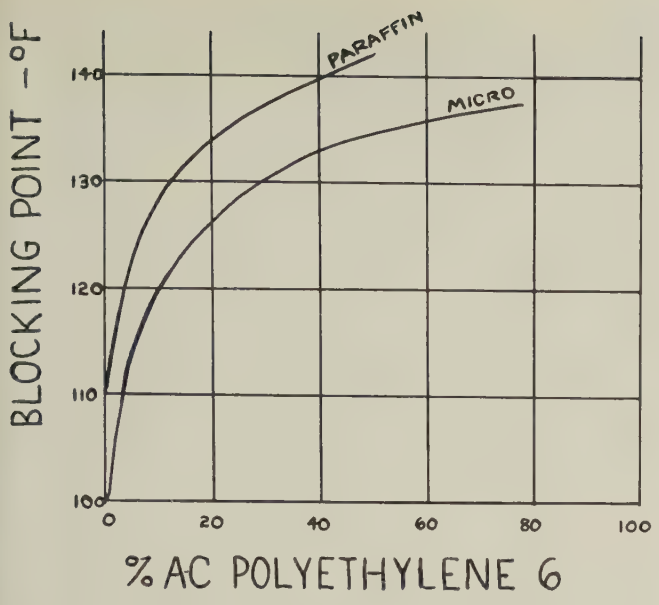

Fig. 4. Blocking point of A-C Polyethylene 6 in wax

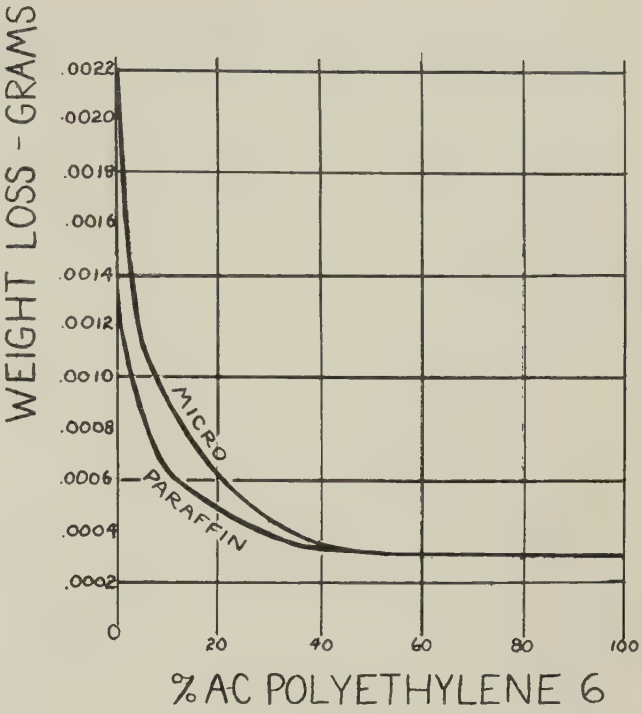

Fig. 5. Scuff resistance of A-C Polyethylene 6 in wax

waxed paper and many methods are in use. Our laboratory uses two procedures neither of which is completely satisfactory. The scuff tester developed by Marathon involves drawing the paper across stainless steel scuffing blocks with 64 striations per in. The striations are 0.010 in. deep and 0.005 in. wide at the exposed surfaces. The blocks are loaded with a 2000-g. weight. The wax removed is determined by weighing the paper before and after scuffing. Results are shown in Fig. 5. A Taber Abraser was also used to measure abrasion resistance and as shown in Fig. 6 the addition of polyethylene improved scuff resistance. These tests were run on coated paper as the rough surface obtained on corrugated did not give reproducible results.

Chemical Resistance. Polyethylenes have excellent chemical resistance. The low molecular weight polymers do not give good grease resistance at the score lines but are superior to paraffin in this respect. Frequently, coatings fail in grease resistance due to pinholes in the coating rather than because of a lack of resistance of the blend.

Gloss and Gloss Retention. Low molecular weight polyethylenes increase the gloss of wax-type coatings. Not only is initial gloss improved but gloss retention after exposure to heat or handling is also better.

Release Properties. Polyethylene changes the feel of waxes to a more plastic type with good release properties. Some powdery or sticky materials which adhere to paraffin, release readily from polyethylene-wax blends.

APPLICATIONS

Formulations. It generally requires at least 20% A-C Polyethylene 6 in wax to obtain the desired properties and most formulas contain from 20 to 50% polyethylene. When higher percentages of polyethylene are used the 1500 molecular weight A-C Polyethylene 617 is frequently employed because of its lower viscosity.

Mixing Procedures. Low molecular weight polyethylenes dissolve readily in wax at temperatures of about 250°F., using a propeller type stirrer or circulating pump.

Table II. Softening Point of A-C Polyethylene 6 in Paraffin

ACP, %	°F.
0	142
1	146
2	148
3	150
5	151
10	155
20	176
35	192
50	203
100	230

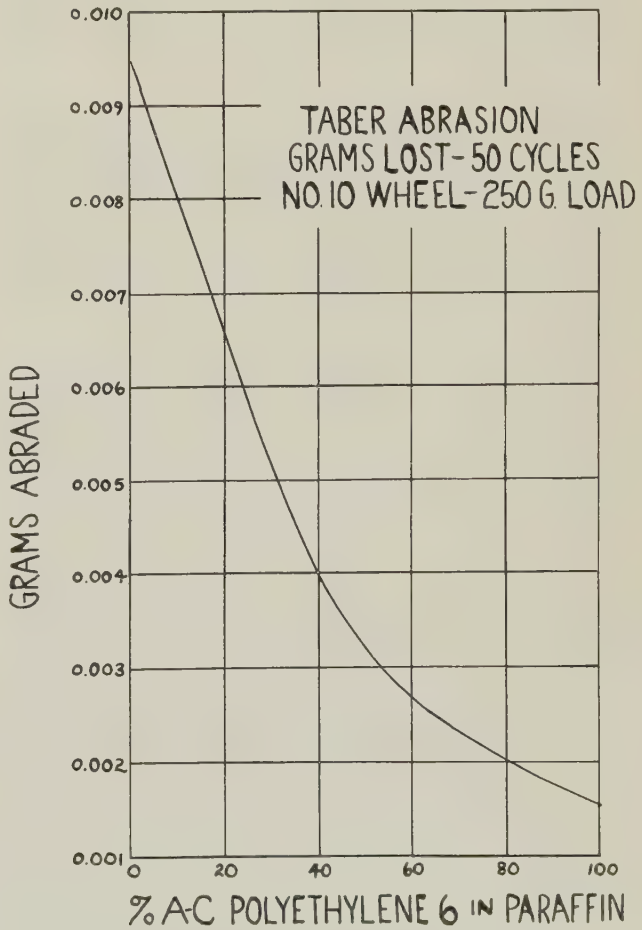

Fig. 6 Taber abrasion versus per cent polyethylene

Waxer Operating Conditions. A 20% polyethylene coating would usually be run with a wax temperature of about 205 to 220°F. A 100% low molecular weight polyethylene coating would require temperature of about 250 to 300°F. The distance between the rolls is adjusted to the minimum which does not crush the board.

Table III. Weight of A-C Polyethylene 6 Paraffin Coatings

A-C Polyethylene 6 in Paraffin, %	*Coating weight, lbs./100 sq. ft.*
0	7
2	7
5	6
10	6
20	5
40	4
60	3
100	6

Coating Weight. The higher setting point and increased viscosity reduce penetration into the board and often result in substantial reductions in wax consumption. The results of one series of tests are shown in Table III. The weight distribution is also changed. With paraffin only about 10% of the total wax may be on the surface whereas the polyethylene-wax blends have 30 to 80% of the total coatings weight as surface wax. This surface wax is necessary to eliminate fiber scratching and give good functional properties.

Scoring. Scoring prior to coating results in heavy buildup of the wax in the score lines with subsequent flaking. Scoring after coating eliminates this difficulty.

Sealing of Cartons. It is not practical to drive the coating into the board or burn it off as is done with paraffin. For this reason conventional adhesives are not satisfactory for use with corrugated coated with polyethylene wax blends.

END USES

The main application for polyethylene-wax coated corrugated has been for packaging appliances and furniture. The good scuff resistance and lack of fiber scratching have in some cases eliminated the need of the cellulose wadding cushioning. Grease resistance to common oils is over 5 days and this is of interest for packaging bakery products. The excellent release properties permit packaging of such tacky materials as some of the synthetic rubbers.

SUMMARY

Low molecular weight polyethylenes modify waxes by increasing melting point, hardness, chemical resistance, scuff resistance, gloss and gloss retention. The low viscosity allows high percentages of polyethylene to be run on conventional waxing equipment. Formulas for corrugated board coatings usually contain 20 to 50% polyethylene and are run at temperatures of 205 to 250°F. The reduced penetration into the board results in considerable savings in wax consumption. Coating prior to scoring is recommended to avoid wax buildup in the score lines. Chief uses have been for packaging furniture and appliances, bakery products, and tacky materials.

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Presented at the 43rd Annual Meeting of the Technical Association of the Pulp and Paper Industry, New York, N. Y., Feb. 17–20, 1958.

A-C Polyethylenes referred to are produced by Semet-Solvay Petrochemical Div., Allied Chemical Corp.

Some Practical Considerations on the Preparation and Use of Synthetic Fiber Papers

R. S. BRISSETTE AND N. R. ELDRED

THE purpose of this paper is to make public for the first time the results of some three years of development work by Union Carbide on several new concepts in the preparation and use of synthetic fiber papers. These development efforts have concerned two fiber products—Dynel, a copolymer of vinyl chloride and acrylonitrile, and Fiber B, a high density polyethylene fiber. In this work, we have concentrated on making best use of the basic properties and handling characteristics of these materials in order to develop new approaches to papermaking problems and to contribute some concepts on the potential usefulness of these papers.

FIBER PROPERTIES

Considering the fact that most hydrophobic synthetic fibers sell in the range of $1.00 per lb. versus less than $0.10 per lb. for cellulose, each synthetic must be carefully evaluated for a specific end use before it can be considered at all as a papermaking material. Dynel and Fiber B are true synthetic materials, polymerized from basic organic chemicals. They are hydrophobic, smooth surfaced, and chemically inert. These fibers are manufactured to strict specifications of resin quality, fiber length, tensile strength and elongation values, color and the other controllable variables.

Dynel is a production item widely used for industrial textile applications such as filtration, work clothing, alkaline battery separators, coated fabrics, and related items. It is also widely used in the apparel market. Fiber B is a development product with large potentials in the industrial filtration, electrical, and coated fabric fields.

Table Ia. Physical Properties of Synthetic Fibers

	Cotton	*Dynel*	*Fiber B*	*Rayon (viscose) regular*
Standard tensile, g.p.d.				
Dry	App. 3–3.5	3.3	4.5–5	1.5–2.4
Wet		3.3	4.5–5	0.7–1.2
Elongation, %	3–7	30–42	16.0	15–30
Density	1.54	1.30	0.958	1.46–1.52
Moisture regain, 70°F., 65% R.H.	7%	0.4%	Nil	11%

Table I (in two parts: Ia and Ib) summarizes some of the physical properties of Dynel and Fiber B compared to cotton and viscose rayon. Note particularly the differences in elongation, density, moisture regain, and effects of heat. All of these properties can be utilized in the preparation or the use of synthetic papers. Based on these fiber properties, it is possible to make papers having the properties listed in Table II. The categories of wicking, high moisture absorption, and increased film adhesion will be covered in detail later in this paper. From this list it would appear that there is some contradiction in that we have listed low intrinsic moisture absorption and high moisture absorption as both being properties of synthetic fiber papers. This is not actually inconsistent in that it must be recognized that both the fiber properties and the method of paper manufacture will influence the properties of the resultant paper. It is possible

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Table Ib. Physical Properties of Synthetic Fibers

	Cotton	*Dynel*	*Fiber B*	*Rayon (viscose) regular*
Effect of heat	Decomposes above 300°F.	Strain release starts at 240°F., softening range is 300–325°F.	Sticks at 260°F., melts at 266°F.	Loses strength above 300°F.
Flammability	Burns	Fire resistant—will not support combustion	Burns slowly	Burns
Effect of chemicals	Resistant to alkalies. Attacked by acids	Resistant to acids and alkalies	Highly chemical resistant	Similar to cotton

to make a piece of paper which will not wet at all, or using the same basic raw material, to make another piece of paper which has an extremely high rate of wetting. It should be pointed out also that it is possible using the basic properties of synthetic fibers and cellulose, to make papers with a balanced combination of properties. In some cases, such a fiber blend also will change the economic picture of the product to a more favorable position.

Table II. Synthetic Fiber Paper Properties

Chemical resistance
Weather resistance
Fire resistance
High rates of filter flow
Low moisture absorption and dimensional stability
Resistance to chemical and bacteriological attack
Good electrical properties
Fast rates of wicking
High moisture absorption
Increased film adhesion

HANDSHEET PREPARATION

In the laboratory preparation of synthetic fiber handsheets, certain factors are of prime importance. These are: (1) fiber length and diameter; (2) dispersion in the headbox; (3) sheet formation; (4) release from wire; (5) wet web strength in couching and transfer; (6) bonding of the finished paper.

Table III summarizes the various factors which appear to be most important in the handsheet preparation of synthetic papers. Most of the considerations listed here for handsheets also apply to our experiences using a small fourdrinier machine. There is one exception—wet web strength. To improve this situation, it appears that some modification in the felt section would be advantageous in order to transfer the sheet from the wire to the driers with a minimum of web distortion. Good control of web tensions and the use of a continuous carrier belt would aid greatly in the carry-through of the web from one section of the machine to another. Despite this, we have made papers containing up to 75% Dynel with good success in the wet end operation.

Table III. Handsheet Preparation

	Dynel	*Fiber*
Fiber length, in.	1/8 to 1/2	1/8 to 1/2
Fiber diameter	2, 3, 6, 12, 24 denier (10 to 50 mu)	4 denier (25 mu)
Dispersion in deckle box	Easy with gentle agitation	Addition of "Polyox" resin, coag. grade, or deacetylated Karaya gum aids dispersion
Stock concentration	0.1 to 0.5% solids	0.1 to 0.5% solids
Sheet formation	Good. Drains quickly	Good. Drains quickly
Release from wire	Good	Somewhat difficult
Wet web strength	Weak—add 5% cellulose or resin emulsion to improve	Weak—add 10–25% cellulose or resin emulsion to improve
Bonding	Bonds without resins	Bonds without resins

Fiber Length and Diameter

A mixture of fiber lengths ranging from 1/8 to 1/2 in. usually gives the best results in terms of sheet formation, ease of dispersion, and paper properties. Two satisfactory blends have been: 75% 1/4 in. and 25% 1/2 in. 2-denier Dynel or 60% 1/4-in., 20% 1/2-in. and 20% 1/8-in. 2-denier Dynel. Two-denier Dynel is approximately 13 mu in diameter. This same principle also applies to Fiber B where we have worked mainly with a 4-denier fiber which corresponds to a diameter of about 25 mu.

Since both of these materials are manufactured, it is possible to cut the fibers to the precise length needed for these blends. Normally these fibers are used as straight uncrimped materials, but it is also possible to make some very interesting papers by using a very short crimpled stock. This stock results in papers that are very soft, lofty, and extremely porous. By their nature, such sheets are quite weak unless they are compressed.

Normally it is advantageous to use the finest fiber available in order to obtain optimum sheet formation and the better physical characteristics. For a more porous, open sheet the coarser denier fibers are normally used.

Dispersion

Experiments to date have indicated that the processing finish supplied on Dynel is sufficient to give good water dispersion. The fibers separate well and will remain in suspension with gentle agitation. In certain equipment, some foaming has been noticed. If this is the case, it is suggested that an antifoam agent be incorporated in the finish.

Fiber B in short lengths disperses well, but to disperse the longer fibers it is advantageous to use a small percentage of "Polyox" coagulant-grade water-soluble resin or deacetylated Karaya gum. In either case when working with blends with cellulose, the addition of a low-foaming dispersant appears to aid in the blending of the fibers. The dispersant helps to eliminate two sidedness in the formed sheet and deposition of fibers on the sides of the deckel box or handsheet mold. Amine 220 is a convenient dispersant and gives good results without excessive foaming.

Sheet Formation

When properly dispersed in a very dilute stock mixture containing approximately 0.1 to 0.5% solids, Dynel forms quite well on the wire. It is necessary, however, during agitation in the headbox to avoid the use of any equipment which provides areas for entanglement of the longer fibers and to reduce the dwell time between agitation and draining of the headbox in order to avoid flocculation of the longer fibers. Due to the extreme freeness of the synthetic fiber stock it is important that the headbox be drained as fast as possible in order to utilize best the water flow in forming the sheet. The use of a blend of short and long fibers greatly aids in the evenness of the formation of the sheets.

The use of "Polyox" resin or deacetylated Karaya gum aids in the formation of Fiber B handsheets and appears to give

slightly better dispersion of the fibers. Approximately 1 part of "Polyox" resin, dissolved coagulant grade, to each 50 parts of fiber by weight appears to be sufficient to give adequate dispersion and formation.

Release from Wire

After couching the sheet to remove excess water it is, of course, necessary that the paper release easily from the fourdrinier wire. Thus far no particular difficulty has been encountered in getting Dynel to release from the wire and in some cases it appears to leave the wire, if anything, a little better than cellulose.

Fiber B, possibly due to its inherent softness, has presented more of a problem in obtaining release from the wire. The addition of "Polyox" resin for better dispersion also appears to help somewhat in the release problem, because it helps to hold the sheet together. However, considerable care must still be taken in order to preserve the integrity of the paper when it is removed from the wire. It would appear possible that a different type of wire, perhaps a finer mesh, would aid in this problem.

Wet Web Strength

Thus far in this talk, we have considered papers of 100% Dynel and 100% Fiber B sheets or as close to this as is feasible. Possibly the greatest problem encountered in the formation of synthetic papers either in handsheets or machine operation is the tendency of the sheets to fall apart before bonding. This can happen during the transfer from the wet end to the dry end, or during any other type of bonding operation. The smooth, inert surfaces of the fibers do little or nothing to contribute to the strength of the material and therefore some new method must be employed in order to compensate for web weakness. Several modifications of techniques have been tried with varying degrees of success in attacking this problem, which, in the case of a machine operation, is a combination of material and mechanical conditions. With Dynel, it appears that the addition of 5% of a well beaten cellulose pulp is sufficient to give adequate wet web strength to the sheet to enable it to be handled easily through the bonding and drying operations. The presence of this small amount of cellulose does not appear to affect the bonding efficiencies, and, where the presence or cellulose can be tolerated in the end use, it is certainly the most economical and easily handled method for obtaining wet web strength. Where the use of cellulose is inadvisable, a low percentage of a polyvinyl acetate emulsion has been found to be satisfactory.

In working with Fiber B, it has been necessary to go as high as 10 to 25% cellulose in order to gain the same amount of wet web strength as obtained with 5% of cellulose in a Dynel sheet. In some cases, again, where the properties of the synthetic fiber alone are wanted, a resin emulsion can be used in low percentages to gain the needed wet web strength.

Bonding

In the hope of retaining the basic characteristics of Dynel and Fiber B, except for the use of polyvinyl acetate emulsion, very little work has been done on the use of resins to bond the sheets. Instead, development work has concentrated on techniques wherein the fibers could be bonded one to another and achieve the fibrous, porous characteristics of a piece of paper. This work has now reached the stage where a continuous bonding technique for both Dynel and Fiber B appears to be practical and adaptable to various types of equipment.

For a number of years various products have been made from Dynel fibers in which a textile type of web is formed and then bonded through the use of heat and pressure in a calendering operation. Such products are strong, uniform, and retain the porous characteristics and flexibility of a fibrous product. Dynel in its fiber form is essentially a crystalline structure as are most oriented thermoplastic materials. Upon heating this fibrous material the plastic will revert to a more amorphous state. However, Dynel fiber always seems to retain a certain degree of crystallinity through its softening range. This usable softening range starts at about 250°F. and extends to about 350°F. Because of this retention of crystalline properties, Dynel, although it becomes tacky on the surface, does not melt or flow as do most thermoplastic resins, such as the vinyls or polyethylene. It is this retention of fiber properties in the softening range which permits Dynel products to be molded, shaped and bonded without forming films.

It is possible to bond dry 100% Dynel sheets by passing them through a heated calender with roll temperature of approximately 300°F. and a nip pressure of several hundred pounds per linear inch. Starting with this knowledge, additional work has been done to improve bonding conditions, and the results of this work are outlined in Table IV. These

Table IV. Bonding 100% Dynel

Furnish: 60% 1/4 in., 20% 1/2 in., 20% 1/8 in.—2-den. Dynel
Equipment: Three roll positive pressure calender set for 100 lb. in. of nip

	I	*II*
Additive for wet web strength	5% Polyvinyl acetate	5% Cellulose
Solvent	5% Propylene carbonate	5% Propylene carbonate
Temperature, °C.	140	140
Speed, f.p.m.	25	25
Bursting strength (points/100 lb.)	110.5 (59 p.s.i.)	187 (100 p.s.i.)

bonded sheets are characterized by having smooth, firm surfaces, good porosity, even appearance and, under certain conditions, a high degree of extensibility. In the case of sample 2, Table IV—the paper did not actually burst under the Mullen test conditions but merely stretched to conform to the shape of the rubber diaphragm. The work absorption property of such papers is, of course, very high and is not reflected in the tensile strengths which run somewhat lower than comparable sheets of kraft or similar types of papers.

The use of propylene carbonate, a high boiling solvent, is desirable in order to give good bonding at reasonable temperatures and pressures and higher calendering speeds. The water in the propylene carbonate solution evaporates during the pressing and heating operations, leaving a relatively high concentration of solvent at the fiber crossings. The solvent tends to tackify the fibers and promote bonding. A solvent such as propylene carbonate which boils at 242°C. is preferable because it remains active throughout the bonding operation at 130 to 140°C.

Several other techniques have been found to be advantageous in producing bonded sheets. A steel to rubber nip appears to give the best results on thinner papers. With thicker sheets it may be advisable to go to a double-heated nip in order to get better heat penetration of the sheet. In practice, it appears that the proper moisture content of the damp sheet should be 20 to 30%. In the actual calendering operation caution must also be exercised to avoid too long a contact between the sheet and the calender surfaces on either side of the nip. In the wet state this is not too serious, but on the dry side of the nip the untensioned paper will tend to wrinkle and shrink if contact and resultant heating are maintained for too long a time.

It is possible to bond sheets of Fiber B continuously by dampening the papers to about 20 to 30% moisture content and running the wet sheets over a paper drying cylinder, such as the photographic type of drier which is common in paper laboratories. Table V summarizes this technique. Properly done, this results in a uniform sheet with good strength,

high elongation and a completely fibrous nature. In actual practice on a multiroll calender stack, it will be observed that steam is formed in the nip. It is also possible to bond completely dry sheets by subjecting them to steam and a moderate amount of pressure.

Table V. Bonding 100% Fiber B

Fiber blend, 1/8-in.–1/2-in. 4-denier Fiber B
Equipment, paper drier
Condition of sheet, wet
Machine temperature, 129°C.
Bursting strength, 12.3 p.s.i. or 37.6 points/100 lb.

Thus, papers of both fibers have been made to retain all of the characteristics of the synthetic fibers themselves without binder material that might alter the physical or chemical characteristics. Table VI summarizes typical data on Dynel, Fiber B, and blended fiber papers. The textile industry has found in the last few years that through better analysis and understanding of fibers and fiber structures they can engineer fabric constructions to do particular jobs much as a civil engineer works with building materials to develop a desired structure. We feel that this same approach can be applied to papermaking, now that there are various new fibrous materials which can be used alone or blended to develop useful characteristics. In this regard, particularly noteworthy are the effects of blending Dynel with cellulose to produce a marked increase in the elongation of paper and the effect of adding Fiber B to "Dacron" fiber to produce a fibrous material with extremely high elongation, yet chemically inert. Such combinations of natural and synthetic fibers can be assembled in a wide range of porosities, strength, fiber structures and paper characteristics.

Table VI. Physical Data on Dynel, Fiber B, and Blended Fiber

Type paper	*Method of bonding*	*Tensile Strength, kg/15 mm.*	*Elongation, %*	*Bursting strength (points/100 lb)*
100% Dynel	Solvent	3.1	8.4	110
Fiber B	Wet	0.6	100	Stretched
50% Dynel, 50% cellulose	Wet	1.9	6.8	30.2
50% Fiber B, 50% "Dacron"	Wet	1.9	28	....

Basis weight: 43 lb. (25 × 40—500).

SPECIAL PAPER PROPERTIES

As a result of a number of market surveys run by various companies concerned with the use of synthetic fibers in the paper industry many areas of end use have been suggested and investigated. In many cases these end uses are predicated upon using synthetics in virtually 100% form in order to take advantage of such properties as rot and mildew resistance, chemical resistance, electrical properties, and other characteristics inherent in synthetic fibers. This approach is certainly sound to the degree that papers made from the proper fibers appear to have a definite potential in such uses as chemical filtration, battery separators, electrical insulation, and the like. However, we now feel that perhaps the biggest potential for the eventual application of synthetic fibers is in the area of blends with cellulosic materials. Blending with cellulose accomplishes two objectives: (1) reducing cost, and (2) most always improving the machine performance of the sheet. In addition, however, it is possible to build into blend papers certain new characteristics that result from combining the particular properties of the component fibers.

One such possible combination of fiber properties is the use of Dynel additives to cellulose to make a grade of saturated filter paper which would have a high degree of porosity and yet a degree of fire resistance. Papers composed of approximately 75% Dynel–25% cellulose are self extinguishing. Naturally any combination of Dynel and resin plus cellulose would be somewhere intermediate in properties between 100% cellulose plus resin and the Dynel-cellulose blend. A reduction in the amount of resin saturate needed will help such things as filter flow-through, flexibility, and drape.

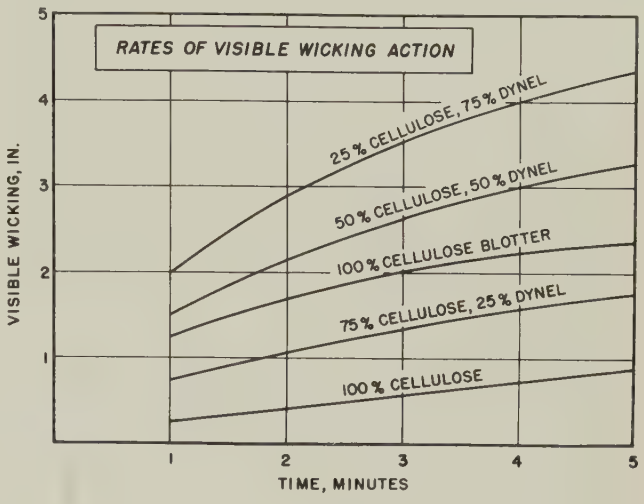

Fig. 1

During our bonding experiments with Dynel papers, it was apparent that products could be made wherein the papers were virtually nonabsorbent. For some applications, this is a highly desirable property. In previous work with Dynel in the textile field it had been found that because of the very irregular cross section of the fiber, Dynel exhibited high wicking tendencies in certain types of constructions. It was felt worth while, therefore, to try and combine this wicking property with the normal moisture absorption of cellulose paper to see what could be produced. The results from this were startling when compared to the results obtained with the bonded sheets formerly tested.

Figures 1 and 2 summarize some of our data on the rate of wicking of water in Dynel-cellulose blend papers and the total water absorbed in these papers. Referring to Fig. 1, it will be noted that the rate of water absorption for papers made of blends of Dynel and cellulose increases very rapidly with higher percentages of Dynel. Likewise, as shown in

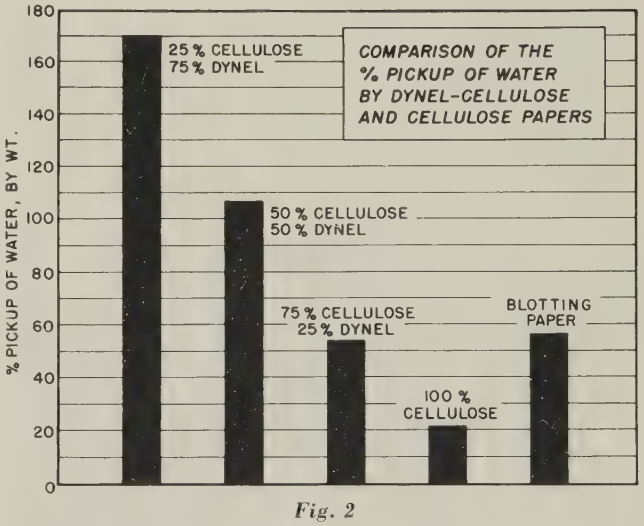

Fig. 2

Fig. 2, the inclusion of Dynel in these papers greatly increased the total amount of water picked up by the sheets.

The rate of wicking in a vertical strip was chosen as a measure of the rate of absorbency since water was instantaneously absorbed by the papers containing Dynel when an attempt was made to use TAPPI Standard T 432 m-45 which consists of letting 0.1 ml. of water run onto the sheet and measuring the time required for absorption.

In the preparation and testing of these samples several variables were investigated and checked to determine the effects. A sheet of 75% Dynel and 25% cellulose absorbs 250 to 350% as much water as does a sheet of blotting paper and it absorbs water from two to three times as fast depending on the length and denier of the Dynel. Inclusion of 25% Dynel into a sheet of unbleached sulphite paper increased absorbency 100% over that of the sulphite handsheet control. A 100% Dynel paper prepared on a commercial machine showed an increase in water absorbency of 170% over that of blotting paper.

An investigation of the effects of length and denier showed that, while long fibers absorbed more water than short fibers, they absorb water more slowly. Similarly fine fibers absorb more water but fibers with heavier denier absorb water more rapidly.

In all cases these blended papers—regardless of the length and denier combinations—absorbed more water and did it more rapidly than the all-cellulose controls. To characterize this property further, sheets were made in which particular pains were taken to make sure that no extraneous wetting agent was present either as a fiber finish or during paper manufacture. The results from this clean stock were the same as those obtained previously from the standard handsheets.

Table VII summarizes a comparison of wicking properties

Table VII. Comparison of Wicking Properties Alpha-Cellulose Versus Dynel/Alpha-Cellulose

	Time to rise, sec.				*Inches wicked in 300 sec.*	*Liquid absorbed, g/sq. in. wet*
	1 in.	*2 in.*	*3 in.*	*4 in.*		
Alpha-cellulose sheets as received	34	180	..	..	2.5	0.18
Handsheets from alpha-cellulose	28.6	140	..	..	2.8	0.10
75% Dynel, 25% alpha-cellulose	9.7	54.8	267	..	3.1	0.20
50% Dynel, 50% alpha-cellulose[a]	6.5	39.8	116	277	4.1	0.14
Alpha-cellulose as received					0.6	0.19
50% Dynel		(168 sec.)			1.3	0.57

[a] The experiment was repeated using mineral oil.

with alpha-cellulose vs. Dynel-and-alpha cellulose handsheets. Recognizing the fact that papers with high alpha-cellulose content are normally used for saturating grades it was felt that such papers should be included in this series in order to get an accurate comparison with commercial standards. The results here were most gratifying in that the inclusion of Dynel gave essentially the same type of improvement as was evidenced with normal cellulose pulps. It is felt that in paper such as this, where the Dynel is purposely left essentially unbonded, the structure contains a semblance of permanent capillary tubes. Because of the hydrophobic nature of Dynel, these capillaries remain open and free to pass fluids and hold them in the porous structure of the paper.

It may well be that this principle can be applied to improve existing saturating-type papers or perhaps adapt new grades to saturating applications.

Perhaps one of the most important recent developments in the paper field has been the melt extrusion of polyethylene films onto cellulose paper base. A wide variety of film thicknesses is now being extruded onto an equally wide variety of base materials for uses ranging from construction papers to food wrappings and packages. In reviewing the properties of Fiber B, it appeared that some improvement might be evidenced if polyethylene film could be adhered directly to the B fibers. One important consideration here of course is the fact that Fiber B melts at approximately 130°C. versus a considerably lower melting temperature for normal low density polyethylene.

In order to follow through on this application, papers were prepared in which percentages of Fiber B ranging from 2 to 25% were added to both sulphite and unbleached kraft pulps in such a way that the majority of the Fiber B was deposited on one side of the papers. Since polyethylene floats on water, this is really not so much of a problem to do as it is to undo if you want a homogeneous sheet. These papers were then melt-extrusion-coated with Bakelite polyethylene resin DXM 121 at $^1/_2$, $^3/_4$ and 1 mil thicknesses to determine whether the presence of polyethylene fibers would improve the bond strength of these coatings.

Table VIII summarizes the results of this experiment. The grams of force required to strip the coating were obtained

Table VIIIa. Force Required to Remove Polyethylene Coatings from Paper Made with Bleached Sulphite Pulp

Series	*Film thickness, mils*	*Force required to strip coating from $^1/_2$-in. sample, gr.* *Fiber B, 0%*	*Fiber B, 10%*
A	0.5	2	7.5
B	0.75	3.25	5
C	1.0	4	20

on a table model Instron tensile testing machine. It was found that polyethylene coated papers can be made to have excellent bond strength by incorporating surprisingly small amounts of Fiber B in the paper. As little as 2 to 10% Fiber B on the weight of the paper increases the force required to strip the coating by 4 to 15 times. This application, we feel,

Table VIIIb. Force Required to Remove Polyethylene Coatings from Paper Made of Unbleached Kraft Pulp

Series	*Film thickness mils*	*Force required to strip coating from $^1/_2$-in. sample, g.* *Fiber B, %* *0*	*2*	*10*	*25*
A	0.5	2	7.5	27.5	24
B	0.75	1	2	7	37.5
C	1.0	8.5	18.5	25	30

is another instance in which the basic fiber properties of the synthetic can be combined with those of the normal cellulose sheet to advantage.

Many different grades of papers containing synthetic fibers can be prepared from a wide variety of base stocks. The major problem remaining is to find volume uses for these papers which justify the additional cost of the synthetic. This justification can result either from new properties or improvements in existing properties. We feel strongly that the major contributions to be made by the fibers industry are to characterize the properties of the fibers now available; to relate these fiber properties to paper properties, both in 100% synthetics and in blends; and to define these paper properties in terms of practical end uses. We intend to continue our efforts along these lines and will make available to the trade whatever data we develop which may help expand the uses of synthetic fiber papers, and, we hope, ultimately expand the markets for papers in general.

Some Considerations of Stock Preparation

M. N. MAY

Stock preparation is an exceedingly broad subject which means different things to different people. The paper maker working with waste paper may think of stock preparation as a means for disintegrating and dispersing the fibers in his raw material; the manufacturer of certain printing grades may think of stock preparation as a means for achieving formation, bulking characteristics, or surface properties; still other paper manufacturers are more interested in stock preparation from the standpoint of strength development. For obvious reasons it would be rather difficult to attempt to cover all aspects of this subject, so, for the most part, I will try to confine my remarks to this last area—the area of strength development.

Let us consider some of the things which take place when fibers are subjected to mechanical action in the presence of water. The chemical properties of the fibers do not appear to be greatly altered in this process; the effects are more physical or physical-chemical in nature. A bruising, splitting, and crushing of the fibers takes place; the fibers swell and become "fibrillated." The primary wall, which tends to inhibit swelling, sloughs off, contributing in part to the creating of fines and debris. There is a reduction in fiber length which in some cases may be quite pronounced. Through the fibrillation of the secondary wall and the creation of fines and debris, the surface area of the pulp is substantially increased. All of these things take place to some extent in every beating or refining operation; however, the extent to which each of these effects takes place—relative to the others—will vary with the design of the equipment and the conditions employed.

If all of these things take place in stock preparation, one might ask—which of the effects are more valuable? This, unfortunately, is a very awkward question, even to try to answer, since effects that may be desirable for one purpose may not be desirable for another. If formation is a prime requisite, then fiber length reduction may be favored; if tearing strength is desired, then an effort will be made to preserve fiber length. I am probably guilty of oversimplification in this type of generalization, however, for many complex factors are involved. To illustrate, let us take the comparatively simple case of tensile strength in paper. Once there was a feeling that tensile strength was largely the result of mechanical entanglement of the fibers. This has been disproved, for the most part, and Swanson (*1*), in reviewing fiber bonding, cites the following points as evidence of this:

"1. When water in a wet sheet is displaced by an organic solvent and the sheet is dried, very little or no strength exists.

2. When the water in a wet sheet is frozen rapidly and sublimed below the freezing point, the sheet is very weak.

3. Sheets formed from pulps suspended in dilute solutions of surfactants are very weak.

4. Certain pulps, which fibrillate extensively upon beating, will not yield strong paper even when both the beating and sheet preparation are done in water.

5. Perhaps most convincing of all—load-elongation studies—show that papers exhibit both "primary creep" and "secondary creep." Strain-hardened papers from which secondary creep has been removed may be repeatedly strained and relaxed without damage to their structure. This would hardly be expected if paper strength depended primarily upon frictional effects."

The principal factors which do appear to be involved in tensile strength may be listed as follows: (1) intrinsic fiber strength; (2) fiber-fiber bonding; (3) fiber length and shape, as they would influence stress distribution through the geometry of the system; (4) sheet formation, which is also manifested through its influence on stress distribution.

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Under fiber-fiber bonding there are several factors involved, such as the surface available for bonding and the nature of the surface, the bonded area per unit of surface area available, and the bonding strength per unit bonded area.

Let us consider now how these factors influencing tensile strength in paper are affected in stock preparation. Intrinsic fiber strength within fairly wide limits does not appear to be influenced by beating or refining—at least to the extent that this property is indicated by zero-span tensile tests. The capacity for fiber-fiber bonding is very much influenced by beating and refining in a variety of ways, which unfortunately are not too well understood. Swelling seems to play an important role; this was indicated years ago by the work of Kress and Bialkowsky (*2*) who showed that bonding would not occur if the fibers were beaten and formed into a sheet in a nonswelling liquid. The creation of new surface area appears very important, but the effect of increased surface area on tensile strength is not at all straightforward. Much of the increase in surface area on beating or refining occurs through the creation of very fine debris which contributes little if any to tensile strength. At the same time there are high surface area fines formed, apparently fibrils or bundles of fibrils, which seem, in some measure at least, to contribute substantially to tensile strength. This seems true, at least, in the usual case of commercial interest where tensile strength is still in the ascending portion of the degree of beating curve.

The chemical nature of the surface exposed on beating or refining, as, for example, the degree of lignification, also appears to be a factor of some importance with regard to fiber-fiber bonding. A highly lignified fibrous material, such as newsprint grade of groundwood, may have approximately the same surface area as a fairly well beaten sulphite pulp; yet the degree of bonding in sheets made from these two materials is quite different. This is not meant to imply, however, that a difference in degree of lignification is the only factor acting in this example to produce differences in degree of bonding. Other factors such as fiber flexibility, the geometry of the structure and, more particularly, other physical and chemical differences of the surface itself, are probably involved.

Fiber length reduction seems to have a rather complex influence on tensile strength. Reduction in fiber length through a purely cutting action has been observed by Clark (*3*) to reduce tensile strength, apparently through its influence on stress distribution in the zone of failure. Fiber length reduction generally tends to improve formation, however, and this tends to increase tensile strength by avoiding local stress concentrations. Thus, there are, even in this simple case of fiber length reduction, competing influences on tensile strength. In most if not all commercial methods of stock preparation, fiber length reduction through pure cutting is not a major factor. Fiber length reduction occurs more through the splitting off of fibrils, the erosion of the primary wall, and the breaking of whole fibers into fiber fragments. There is some evidence in the literature indicating that maximum tensile cannot be developed in a pulp unless some fiber length reduction takes place. Jayme (*4*) in a comparison of ultrasonic refining with more conventional refining, found that tensile strength showed improvement with increased ultrasonic refining to a certain point, and then changed very little. However, further improvement in tensile strength could be produced by refining this same pulp in a beater. Jayme explained these results by stating that a certain amount of short fibers are necessary for maximum tensile strength. Ultrasonic irradiation appears to remove the primary wall of the fiber in the form of debris and produces fibrillation of the secondary wall. However, it does not appreciably alter fiber length. These results suggest that mashed or torn short fibers are necessary for the additional strength improvement. These studies of Jayme did not include a measurement of sheet formation which may have had a substantial influence on the results.

With regard to sheet formation, stock preparation is of course only one of a great many complex factors influencing this paper property. The fiber length reduction aspect of stock preparation generally has a favorable effect on formation, whereas fibrillation, or at least some of the effects accompanying fibrillation, seems to have an adverse effect. In any event, the extent to which formation is influenced by stock preparation will have an accompanying effect on tensile strength.

We have considered some of the things which take place in stock preparation and qualitatively, at least, how these changes influence the factors which combine to determine tensile strength in the ultimate sheet of paper. It would be most fortunate if we could put these relationships into quantitative terms so they could be used to specifically design a piece of equipment to do a particular job. Unfortunately, this goal is still a long way off, but there have been some very interesting steps in this direction over the years. Some 30 to 35 years ago, Smith (*5*), Milne (*6*), Kirchner, and others made some very interesting mathematical analyses of the action of the hollander beater. Smith and Milne attempted to divide the beating action into the separate functions of cutting and wet beating, with cutting being related to the number and length of bar edges that came into contact per unit time, and wet beating being a function of the bar contact area. Smith also introduced the concept of fibrage into beating, which he found useful in explaining some of the effects of consistency on beating. Smith hypothesized from some simple experiments that the stock forms a mat on the leading edges of the flybars and bedplate bars. He termed this mat "fibrage" and postulated that the quantity of fibers contained in the fibrage was a function of fiber length and consistency. He also postulated that a certain amount of circulation in the cell space between bars was necessary to permit the fibrage to be renewed, and that this circulation was a function of bar spacing. This explained the fact that some beaters with relatively narrow bar spacing were less efficient than ones with wider bar spacing. Milne sought to employ the concept of inch cuts per minute per pound of stock, and square inches of beating surface per minute per pound of stock to determine the capacity of beaters and their ability to perform "wet beating." The term "inch cuts per minute" was defined as the product of the number of fly bars, the number of bedplate bars, the length of the bars, and the number of revolutions of the beater roll per minute. The term "square inches of beating surface per minute" was referred to by Milne as the "capacity for wet beating" and was defined by the product of the number of fly bars, number of bedplate bars, thickness of the fly bars, thickness of the bedplate bars, the length of the bars, and the number of revolutions of the roll per minute. Milne came to the conclusion that the ratio of "capacity for wet beating" to inch cuts per minute should be greater than the ratio of $^1/_{32}$ for effective strength development. I am sure that many people have since concluded that this is an oversimplification, but it represents an interesting attempt to quantitatively differentiate between some of the simultaneous phenomena occurring in beating.

The work of Milne and Smith neglected factors which some of the workers in this field now feel to be of some importance, such as the "sharpness" of the tackle, or radius of curvature of the leading edges of the bars, the materials from which the bars are constructed, and the nature of the bar surface. There are difficulties, also, in attempting to apply the results of Milne and Smith which were obtained in studies on beaters to the design of the conical and disk refiners which are in such wide use today. This difficulty may in part be due to differences in the path of the fiber in relation to the direction of motion of the bars, and to differential speed effects arising from the differences in the linear velocity of the bars as the fibers proceed along the cone or outward along the face of the disk. However, the systematic method of mathematical analysis employed by Smith and Milne certainly should be commended, and a similar mode of attack with modern refiners might be profitably employed.

Besides factors involved in the design and construction of refiners, there are process variables which have important influences on the properties of the refined pulps. Consistency, temperature, pH, and the presence of various ions should certainly be on the list of such variables. It is generally accepted that increasing consistency increases "fibrillation" and decreases "cutting" of the fibers. This is at least qualitatively in keeping with the fibrage theory of Smith, and the role that consistency plays in forming fibrage. Temperature, pH, and the presence of ions seem to render their influence through their effect on the colloidal behavior of the fibers.

Centola and Borruso (*7*) and others in the field have advanced the hypothesis that beating of pulp should be related not only to defibering the cellulose fibers on a microscopic scale (fibrillation) but also to submicroscopic effects. The latter could be due to the solvent action of water on the amorphous zones of the outermost layers of the cellulose fibers which, aided by the mechanical action of friction, would partly free some macromolecules of polymeric carbohydrates, which for a certain length, would project into the water. This projecting layer must obey all of the laws that govern the behavior of colloidal systems. Centola and Borruso point out that the effects of temperature and electrolytes fit this picture:

1. Temperature increase favors coagulation of the cellulose gel and recrystallization of the cellulose. This is reflected in a decrease in beating rate and increase in freeness with an increase in temperature.

2. Cohen, *et al.* (*8*), show the effect of cations as a direct function of concentration and valence of the cation.

3. Anions do not show the valence effect; they seem rather to operate by ion exchange, replacing anions on the pulp.

The influence of pH on beating seems to be through its influence on the swelling of the fibers with beating rates being faster at high pH than at low pH—at least over the pH ranges most commonly employed in beating and refining.

In conclusion, it must be said that much remains to be discovered about this broad and complex field of pulp processing. Most of the observations that have been made over the years and the relationships which have been established are at best qualitative, and much remains to be done before the design and operation of stock preparation equipment can be put on a quantitative basis. We need better tools of pulp evaluation and a much better concept of the complex mechanisms whereby the changes which take place in stock preparation achieve the properties that we want in the final sheet of paper.

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Selecting Coating Methods

A. F. BOBRESKI

SINCE there are many phases associated with the problems of coating, the one discussed in this paper will be connected with the title just mentioned. In this paper, little or no mention will be made of the necessary auxiliary equipment such as drives, winders, unwinds, controls, drying or curing ovens which are all very important in realizing a satisfactory coated web.

Information for this paper was acquired through actual experience in coating projects using a pilot plant coater, discussions with people working with coatings, and field service work.

When a party becomes involved in evaluating coatings and develops the desired coating, he is confronted with the problem of selecting the coating method for applying his coating. At this point, mention is made of the fact that the most important thing in any coating operation is a properly formulated coating for commercial coating application. A properly formulated coating for one set of conditions may be entirely inadequate for another set of operating conditions. One can usually modify a coating formulation to a coating method but one cannot readily modify the coating method to the coating material.

The coating methods that will be discussed for coating application are the following: (1) air knife, (2) spray, (3) gravure, (4) knife blade, (5) cast, (6) smooth roll, (7) dip, and (8) trailing blade.

The foregoing by no means limits the coating methods available but will serve as a guide in selecting the desired coating method. From this guide, any combination of special or complex machine coating methods can be used.

In discussing the various coating methods, the desirable characteristics as well as the corresponding shortcomings of any specific coating method are mentioned. No inference of any kind is intended in any way, shape, or manner that one coating method is better than another. In fact, it would be difficult to prove this. In other words, each coating method has its particular limitations and must be considered for each specific iob.

There are two types of coating methods; these are "off the machine" coating of which most of the preceding methods are applicable and "on the machine" coating. As the names imply, "off the machine" coating is done separately on a paper web after it has been moved to a converting plant. "On the machine" coating is done on the paper machine before the paper is wound.

Before starting on the coating methods, it may be well to review some reasons for coating paper and other webs. Some of the reasons are: (1) general upgrading of web; (2) water and moistureproof properties; (3) solventproof properties; (4) greaseproof properties; (5) limited weatherproof properties, such as billboard paper; (6) resistance to scuffing, abrasion; (7) heat sealing properties; (8) improve printability as well as masking original surface appearance of paper; (9) sales appeal; and (10) others as requirements dictate.

Once a converter or interested party knows he has the desired coating formula through simple preliminary drawdown tests, he then wants to know the commercial coating application for his purpose. In many cases an original coating formula was satisfactory as predetermined in simple drawdown handsheet tests, but was not suitable for commercial coating application because of such conditions as sensitivity to shear properties (inherent to many emulsion coatings), gelling or solidification, solids separating, lack of proper solvent and others. In such cases, coating had to be reformulated.

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The coating methods previously mentioned have certain inherent features. These are now briefly discussed.

Air Knife Coating

This method has one main characteristic. This is the fact that the coating will conform to the surface of the web. Because of this paperboard, paper and an embossed surface can be coated satisfactorily. The method of application calls for applying an excessive amount of coating to the web by a pickup roll. This excess is then doctored off by a narrow stream of air from the air knife. Since the stream of air used for metering control is dimensionless, it will shear off excess coating and leave an image of the original surface present. This can be used particularly to advantage with an embossed surface since the pattern will be retained. Also, if the surface requires a smoother appearance, as is true in many cases, calandering operations can be used.

Coating weights can range from approximately 3 to 20 lb. per ream (24 × 36—500). They can be controlled to a degree by the coating viscosity solids content, and by the inlet air pressure which generally may vary from 1 to 6 lb. gage pressure.

Spray Coating

This method has as its main characteristic the application of a premetered amount of coating in spray form. Because the spray is dimensionless, it can be applied to relatively porous surfaces, irregular shapes, or rough surfaces. If application methods were used on the porous webs whereby an excess were applied and subsequently doctored off by any of the conventional manners, some of the excess would initially soak into the porous surface and could make the process economically unsound. Spray coating is generally not considered for a relatively smooth flat surface as it is difficult to realize satisfactory control and a completely uniform coating especially when any application variable is changed.

A very important requirement of spray coating is the use of a relatively low solids content and dirt free coating so as to prevent the nozzles from becoming plugged and provide almost absolute uniform pressure controls.

Gravure Coating

This method has as its main characteristics the application of a very uniform, lightweight coating on a relatively smooth surface, especially as in carbon paper or in transparent film using both gravure and offset gravure methods. This is especially important when applying hot melt inks. The importance of this uniform, lightweight application can be appreciated by the fact that the coating desposit of a hot melt ink cannot usually be measured by a micrometer on a single sheet. A simple accurate means would be a light intensity variation method. This involves using a bright light source on the opposite side of the coated web for checking nonuniformity of coating weight by the varying intensity of the light source. This is a quick nondestructive, dimensionless test method that can also be applied in other cases.

The inherent drawback of gravure coating is its rather limited application when different coating weights or webs are used. The coating weight could be changed in a limited range by the solids content of a solution coating but not for a hot melt ink which is 100% solids. Different coating weights would require a roll with a different pattern.

One time and multiple carbon paper is usually coated by a gravure method. Plastic films can also be coated by either direct or offset gravure when a low coating weight is desired.

Knife Blade Coating

This method has for its main characteristic over-all simplicity and is generally used for coating relatively porous materials like cloth, felts, blankets where a rather smooth heavy coating application is necessary. Paper is rarely

coated by this method. A high solids, high viscosity coating can be used.

The knife blade is a stationary, rigid blade usually with a bullnose edge although other type edges can be used. Please note the similarity of this coating method with trailing blade method discussed later on. The coating method is relatively simple in that the coating is applied somewhere before the knife and is doctored by the knife at line of contact.

The main disadvantage of the knife blade is its difficulty (in most cases) to control when applying a lightweight, uniform film. For one thing, it is very difficult to have a perfectly straight surface on the knife blade. Even with a very straight surface for lightweight applications, any variations in paper caliper, tension or the presence of any foreign matter will form a high spot on the surface and cause the paper to tear. This is most annoying and is not practical.

Cast Coating

One of the main characteristics of this method is the superior type gloss finish available without the web requiring supercalendering. The finish is obtained by offset of a very highly polished metal surface onto the coated surface.

The coating is applied to the web surface by coating methods, such as squeeze, reverse roll, knife, or dip roll. The coated surface is directed immediately against the face of the polished drum, dried, stripped away from drum, and rewound. The mirror image of the casting drum is off set onto the web surface. A stainless steel belt could also be used instead of the drum. Another variation of cast coating is to use an inherent release-type surface like cellulose acetate or glassine as a substitute for the casting drum. In this case the coating could be applied to the release type web surface and then have the web, with the surface to be coated, placed over the coated web. The coating is dried and the desired coated web stripped from the release type web and each wound separately on a different winder.

Smooth Roll Coating (Reverse Method)

This method has as its main characteristic an appreciable range of flexibility and is widely used because of the following reasons:

1. Coating thickness on applicator roll will remain relatively constant in spite of varying speeds.
2. Coating weights can be changed easily simply by changing the applicator roll speed for a corresponding coating weight change. This takes place with the line speed remaining constant. This method is also used in controlling a uniform coating weight by installing beta ray gages on uncoated and coated web.
3. Web width changed easily by relocating edge dams or edge doctors.
4. Wide range of webs used.
5. Wide range of viscosities and solids content of coatings can be used with the understanding that these are properly formulated.
6. A smooth and usually shiny film is realized with a film forming type coating. A squeeze-type coating method will give a dull surface.

One of the main restrictions of this type of coating method is that a uniform low coating weight below 6 to 8 lb. per ream is usually not possible. Very light weight porous-type tissues usually cannot be used because of relatively low tensile strength, both dry and wet. This causes paper to stick to rolls by the coating which acts as an adhesive and the tissue breaks.

With a squeeze-type coating method the film is split as with a gravure roll application. The surface film is dull but can be of low uniform weight if necessary as determined by pressure on the rubber back up roll. By adding more transfer rolls, the film is further subdivided for an even smoother surface and lower weight.

Dip Coating

There are two application methods for this type of coating. One is, as the name implies, a dipping either partially or wholly of the web around a roll immersed in a coating solution. The other method, also known as the bead coater, requires the web to remain completely outside the coating solution and become coated by a raised bead or bubble of coating on an applicator roll by a surface tension condition. In the former method, the coating can be applied either to one or both sides of the web depending upon the level of the coating. This method has the features of simplicity in design, operation, and control. The operating controls are the viscosity of the coating, porosity of the web, as well as the dwell time of web in the coating. This method is used for coating linoleum-type felts, insulating papers, and different webs which can be used alone or in laminating operations.

The main disadvantage of this type of coater is that the coating solids content must be rather low when solutions are used and so requires a larger drying oven or the coating requires a fairly elevated temperature when hot melt asphalt coatings are used.

The other type of dip coating or bead coating has as its main feature the application of an extremely fine accurate film thickness. This is probably the most precise type coating available from any of the coating application methods.

This method is used mainly in coating photographic type webs where film thickness has to be extremely accurate and also in the plastic film industry in special cases.

The main disadvantage of this coating method is the relatively low speeds that can be used since any appreciable increase or elevated speed will break the film. Also a very close control of the coating conditions such as temperature, viscosity, and freedom of foreign matter are required.

Trailing Blade

This method has as its main characteristic the ability of applying very low coating weights of $1^1/_2$ to 2 lb. per ream at a relatively high speed of over 2000 f.p.m. This is especially advantageous when one considers a two-coat operation using a prime coat to seal over to prepare a surface for a second functional coating which would be used in a lesser amount than if no prime coat were used.

Coating weight control could be obtained by change in solids content or viscosity of a coating as well as using a different metal doctor that would have a different degree of "spring" or doctoring which would permit more or less coating to pass through. Usually a 0.010 or 0.012 in. thickness doctor blade is used. If a thinner blade is used, a greater degree of spring would possibly permit more coating to be applied to the web.

The above are the main types of coating methods that are usually considered for different applications. With the development of newer coatings and webs and more fundamental research of paper surfaces, it becomes increasingly important that the most satisfactory coating method be used in all cases.

It is the author's opinion that a long range fundamental research program on coating web surfaces with different coating methods would prove very helpful in understanding the differences of these methods. Briefly and generally speaking, it is believed that the program should have some standard items such as the web and coating. The coating could be applied to the web at a specified weight by most of the coating applications methods just mentioned. The surfaces would then be evaluated. This fundamental information could be used as a guide in evaluating coating methods.

An Empire State Section Award paper presented at the meeting of the Empire State Section of TAPPI held in Lake Placid, N. Y., June 10–12, 1958.

A Discussion of the Ring Crush Test

JIMMIE H. SMITH

Our industry is constantly devising new and different tests in order to measure the different qualities of our products. One of these tests which has become of interest to some box manufacturers and linerboard producers in the past few years is the ring crush test.

The ring crush test was designed to measure the resistance of paperboard to edgewise compression. Since some box manufacturers have stressed the desirability of having a high ring crush test in linerboard, some linerboard producers have felt that it was necessary to perform the test in order to measure this quality in their product.

We at Southern Paperboard have performed the ring crush test daily for the past 5 years, but by no means do we advocate its adoption as a control or specifications test. I shall give you the reasons as I proceed. We consider high ring crush test to be an added quality, which if possessed by linerboard, makes it more desirable to some box manufacturers, and we utilize the test only to measure the level of crush resistance possessed by our board.

Before I begin discussing details, let me briefly describe the test for you. First a strip of board $^1/_2$ in. wide, and 6 in. long is cut. This strip is placed in a sample holder which forms it into a circle, with $^1/_4$ in. of the sample protruding above the holder. The holder and sample are then placed in a compression machine, and the force required to crush the protruding $^1/_4$ in. of sample is measured in pounds.

The edgewise compression is measured in both machine direction and cross machine direction, but the box manufacturers are primarily interested in the machine direction ring stiffness for this reason:

The corrugating medium is glued to the linerboard so that the flutes are perpendicular to machine direction. After the sheet goes through the slitter, the relationship between machine direction and top, bottom and sides of the box are as shown in Fig. 1. When the box is fabricated, it can be seen that machine direction runs around the sides of the box, while the flutes are perpendicular to the top and bottom planes of the box.

Any compressive force applied to the top or bottom of a box is resisted not only by the cross machine direction compression resistance of the linerboard, but also by the compression resistance of the flutes of the corrugated medium. However, the only crush resistance offered to a force applied to the ends of a box is that supplied by the machine direction compression resistance of the linerboard.

Some box manufacturers have proved to their satisfaction that boxes made from linerboard which has a high MD ring crush test have a high end to end compressive strength. For this reason, they have stressed the desirability of obtaining linerboard with a high machine direction compression resistance.

In order to give you some idea of what values I am referring to when I say high and low ring crush tests, here are what we consider to be normal values for the different weights of board.

	26	*28*	*33*	*38*	*42*	*47*	*69*
MD	58–63	60–65	79–85	91–98	103–111	112–122	160–170
CMD	41–46	43 48	58–65	68–76	75–83	83–91	127–136

The procedures for determining the compression resistance of paperboard can be found in TAPPI Standard 472 m-51 or in Institute Methods of The Institute of Paper Chemistry, method no. 915 or ASTM method D 1164–51 P. The procedures seem easy to follow but there is many a slip between reading the procedure and obtaining a suitable test result.

Jimmie H. Smith, Southern Paperboard Corp., Port Wentworth, Ga.

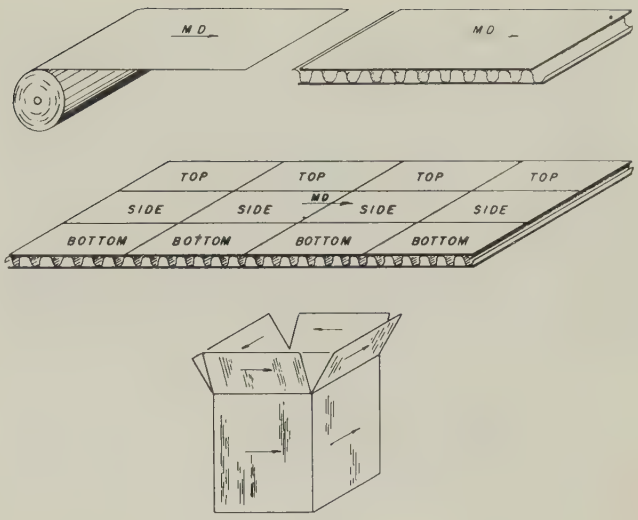


Fig. 1

We have been running ring crush tests daily for the past 5 years and we are still learning.

Since emphasis has been placed on the test by some box manufacturers, I feel certain that many linerboard producing mills will feel the need for performing the ring crush test.

We think that a discussion of some of our trials and tribulations will be of interest and benefit to those of you who are now, or who may be, running the ring crush test. We sincerely hope that some of the lessons learned by us will be of value to you and will enable you to perform the test with a minimum of difficulty.

Let me emphasize that this will be a discussion of the test itself, and of some of the variables affecting the test. I won't attempt to tell you how to get high compression resistance in your linerboard because it is a very elusive quality. It seems to be a quality inherent in a machine. We have made extensive checks throughout the system, from chips to machine, trying to find some factor which correlates with compression resistance, but with no success. After our machine was rebuilt 1 year ago, the compression resistance of our linerboard increased, but I can't tell you why. Our conclusion is that either your machine has it or it hasn't.

The Institute method no. 915, which we follow at Southern Paperboard is practically identical with ASTM method D 1164–51 P, and is similar in some respects to the TAPPI method. I will point out any major differences as we proceed. I shall discuss the apparatus and testing procedure, and elaborate on any points which we have found to be particularly important.

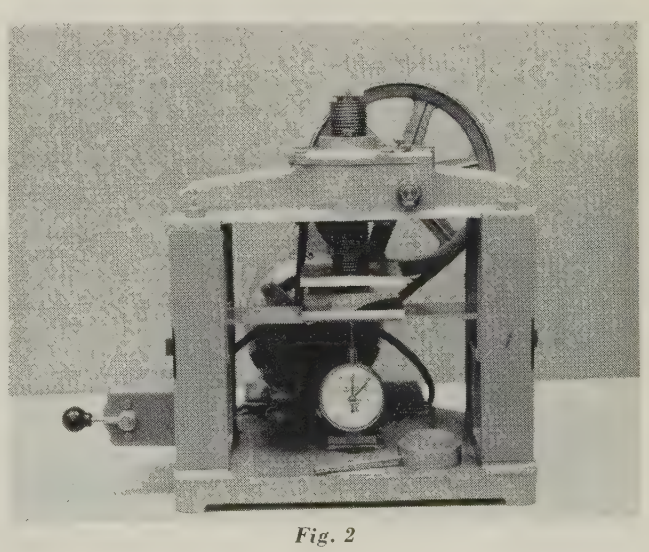


Fig. 2

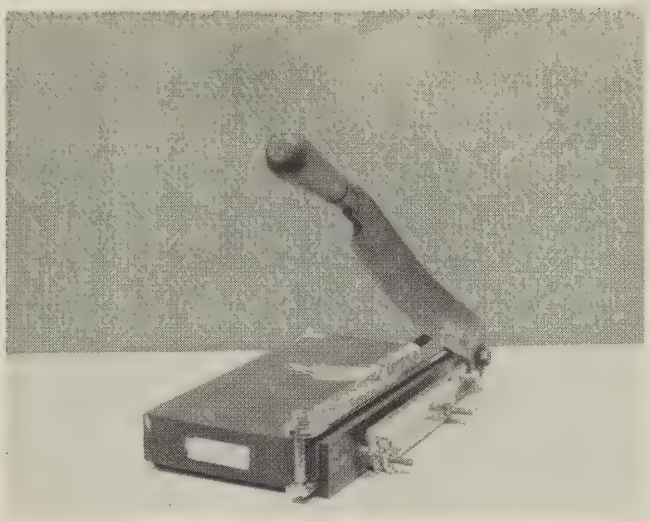


Fig. 3

First there is the description of the compression machine. The machine we use is shown in Fig. 2. Machines which meet these specifications are readily purchased. The TAPPI method differs from the Institute and ASTM methods insofar as platen to platen speed is concerned. TAPPI states that platen to platen speed should be $^1/_2 \pm {}^1/_8$ in. per min., whereas the Institute and ASTM methods state that the platen to platen loading rate shall be 900 ± 300 lb. per min. and platen to platen speed no greater than 1 in. per min. We have done no experimentation to determine the effect of different speeds or loading rates. We have adjusted all of our compression machines so that they have the same platen to platen speed.

Round robin tests have shown that different compression machines of the same design give substantially the same results.

The next piece of apparatus discussed is the specimen holder. The TAPPI method does not place nearly so much emphasis on the holder as does the Institute and ASTM methods. We have found that in order to obtain dependable results, great care must be taken with the manufacture and maintenance of the holder so that it remains within specification limits at all times.

It is extremely important to have the base of the groove parallel to the base of the plate. At one time we experienced a sudden drop in our ring crush tests. Our usual checks failed to find the reason. Finally, upon careful observation of the pressure platen upon descent, it was discovered that the platen did not contact all points along the top edge of the sample simultaneously. Examination of the sample holder showed that it had been dropped on one edge of its base and had suffered a slight dent. This dent raised that particular portion of the plate only a few thousandths of an inch, but it was enough to drastically affect the crush test.

The width of the groove also has an effect on the test. We have found that this effect is not appreciable with low weights of board, such as 26 and 28 lb., but becomes increasingly more noticeable as the weight of the board tested increases. Since 69-lb. board is the heaviest we test, it is with this weight that we have observed the greatest effect caused by groove width.

At first, the only island we had, which would give us a groove wide enough for 69 lb., was one for 90-lb. board. This worked all right for a while until we suddenly began to get low results. Examination showed that not only the exposed $^1/_4$ in. of sample was being crushed, but the portion within the holder was being crushed, too. The groove was wide enough to allow the entire $^1/_2$ in. of sample to crumple. When the correct size island was made and used, this trouble disappeared.

The next piece of apparatus described is the cutter. The specifications state simply that the cutter shall be capable of accurately cutting the specimen with the long edges parallel to one part in ten thousand. It also states that this may be accomplished by means of a card cutter with an adjustable outside guide.

We have experienced more difficulty finding a suitable cutter than we have with any other single item. It seems reasonable to me that none of the cutting apparatus would enable you to get a higher ring crush test than that which was inherent in the board. Consequently, in our search for a cutter we have always concluded that the best cutter was the one which enabled us to obtain the highest ring crush test.

We first experimented with the card cutter type, Fig. 3. This type cutter had several disadvantages: (1) it was necessary to cut a strip of board exactly 6 in. wide from which to cut the sample strips. We frequently found strips which were either too short, or too long. (2) Using this type cutter required extreme care in order to cut strips with truly parallel edges. If the edges are not parallel, then the platen does not touch all points of the sample simultaneously, and a low test is the result. (3) Using this type cutter, the knife blade rubbed against the edge of the sample on the down stroke and on the up stroke, causing a slight bending of the edges. This causes low results. In addition, the pressure of the sample edge against the adjustable bar could conceivably damage the edge.

The next type cutter tried was a parallel blade cutter as shown in Fig. 4. This cutter has a bar exactly $^1/_2$ in. wide. The sample sheet, which has been previously cut to 6-in. width, is placed across this bar. A holding bar decends upon the top of the sample and two blades shear the sheet along the edges of the $^1/_2$-in wide bar. This was an improvement over the card cutter, as it eliminated the possibility of having nonparallel edges, and of edges damaged by contact with the guide. However it was still necessary to have a strip cut exactly 6 in. wide to feed into the cutter. Also, the knives still rubbed against the edges of the sample going down and coming up. Damage to the edges from this action is most noticeable in heavy weights, such as 69 lb. This bending action was corrected by having a new holding bar made. The holding bar supplied by the manufacturer was $^7/_{16}$-in. wide which allowed a $^1/_{32}$-in. wide strip on either side of the sample to flex as the blades rubbed against it. Our machine shop made a holding bar which was $^1/_2$ in. wide. This eliminated the flexing of the sample strip edges, but some damage was still being done by the blades. A good point in favor of this cutter was that sample strips could be cut faster with this parallel blade cutter than with the card cutter.

The third type cutter we have used is a die cutter, Fig. 5,

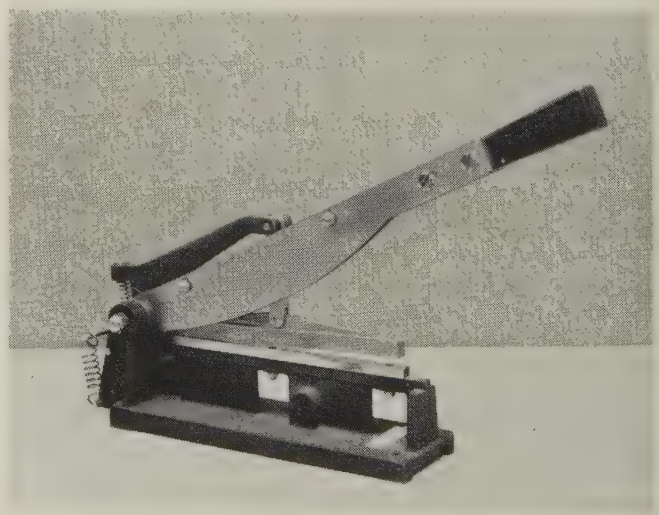
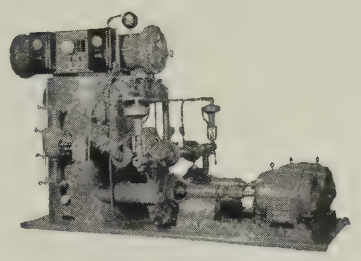


Fig. 4

The ONE Vacuum Pump Made for Paper Mills



The Stickle Vacuum Pump is made exclusively for paper mills. It's easy to service. All floats housed in exterior float boxes. Interchangeable, removable vacuum chamber is above tank. Inspection of ejector tubes may be made without moving motor, pump or piping. Uses standard horizontal motor and pump. For vacuums to 28″. Built-in heat exchanger eliminates costly cooling equipment. Recirculation of hurling water condenses flash vapors and releases air and gases to atmosphere. No close clearances to cause wear. Performance guaranteed. Single and duplex models. Write for free literature.

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which simply stamps out strips 6 in. long and $^1/_2$ in. wide. In our opinion this is the most satisfactory type because it gives sample strips of exact length and width, with parallel edges and a minimum of edge damage. The only trouble we have had with this cutter in over 2 years of use is that it got out of alignment a few months ago and had to be returned to the factory for repairs. While it was gone we returned to the parallel blade cutter and our crush tests dropped 10 to 15%.

On the basis of our experience we recommend that any of you running this test use the die-type cutter.

The test specimens are sampled at four points across the width of the machine at Southern Paperboard. We designate these points as front, front middle, back middle, and back. The samples are preconditioned in a heated box to reduce their moisture content below the equilibrium point which they will reach in the constant humidity room. The samples are then conditioned according to TAPPI Standard T 402-m and are tested in the same atmosphere.

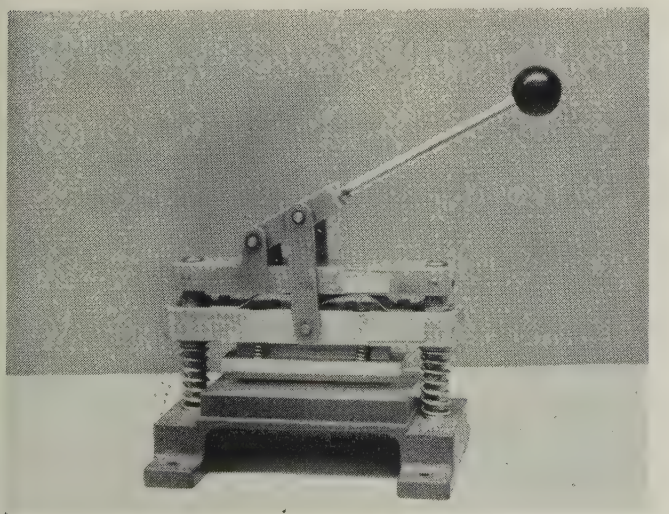

Fig. 5

The mositure content of the samples has a noticeable effect on ring crush tests. We have made no controlled test to determine just how much different moisture levels affect the test, but it has been apparent that when our constant humidity room has too high a relative humidity, our test results are lower than normal, and when relative humidity is too low, tests results are higher than normal.

The testing procedure, as described, is easily followed. Note *must* be taken of the orientation of the test specimen with reference to machine direction and side nearest center of holder. Cross machine direction samples will give a crush which is approximately 20 to 30% lower than samples tested in machine direction. Samples with wire side towards the center of the holder will give test results 3 to 5% lower than those tested with the wire side on the outside. We think this is affected by the curl of the sample. A sheet normally tends to curl with wire side outside the curl. When the direction of that curl is reversed the ring crush test is lowered slightly. During the testing of each set of strips, we alternate wire side directions so this variable will be averaged out.

We use the same method of reporting results as is described in the Institute method.

We feel that the test has the following disadvantages:

1. Since a conditioning period of 24 hr. is required before testing, this could never be a control test.
2. So many variables in the testing procedure itself affect the results that it is extremely difficult to attempt to locate the cause of poor test results.
3. The test has poor reproducibility. In a group of five strips from the same 12 by 12 sheet it is not unusual to find a range of 20 points with an average crush of approximately 110. The higher the weight board being tested, the greater the range.
4. Even the person running the test affects the results. At one time I had to discontinue performing the test because perspiration on my hands was causing me to obtain approximately 10% lower results than another person testing the same batch of sample strips.

However, since some manufacturers of boxes desire to know what ring crush level to expect from a linerboard producer, I feel sure that the test will continue.

Undoubtedly some of you are going to be performing this test at your mills, so in hopes that you will be aided by them, allow me to make the following recommendations.

1. Make sure that your compression machine meets specifications.
2. Take special care to see that your sample holder meets specifications originally, and check it periodically. Have the correct island for each caliper of board being tested.
3. Obtain a die cutter. In round robin tests where all types of cutters were used we have found that die cutters consistently give highest results.
4. Make sure that your constant humidity room maintains temperature and relative humidity within accepted limits.
5. Above all, take every precaution to avoid damaging the edges of your test strips either by cutting or handling.

I sincerely hope that these recommendations will be of some assistance to you. Perhaps if enough of us work on this problem not only will we be able to standardize the test but perhaps we can discover how to improve the compression resistance of our linerboard.

An Award paper presented at a meeting of the Southeastern Section of TAPPI.

UNITED STATES PATENTS ON PAPERMAKING

Third Quarter, 1958 — *Compiled by The Institute of Paper Chemistry*

The following list of United States patents has been, compiled from the current numbers of the Official Gazette of the United States Patent Office. Because, as a rule, only one claim is published in the gazette, it is not claimed that the list is complete; also, it is possible that the list may contain some patents that do not apply specifically to pulp and paper manufacture. Copies of any of the following patents may be obtained from the United States Patent Office, Washington 25, D. C. by sending twenty-five cents for each patent desired. Or, those desiring the patents on microcards should write to The Institute of Paper Chemistry, Appleton, Wisconsin.

July 1, 1958

Bornstein, Leopold F. Method of making thermosetting molding compositions containing filler. U. S. patent 2,841,565. Filed June 15, 1956. 14 claims. [Cl. 260-17.3] The filler is sulphite pulp, alpha-pulp, wood flour, etc.

Clark, Frank M. Electrical cable structure. U. S. patent 2,841,633. Filed December 3, 1956. 9 claims. Assigned to General Electric Co. [Cl. 174-25.] A paper-insulated cable is described.

Clement, Joel. Apparatus for sealing containers. U. S. patent 2,840,968. Filed March 9, 1956. 3 claims. Assigned to La Cellophane. [Cl. 53-198.] The machine seals containers with pressure-sensitive tape, a tear string being provided in each closure.

Costello, James R., Jr., and Traise, Thornton P. Method of flameproofing fibers and composition used therein. U. S. patent 2,841,507. Filed Sept. 22, 1953. 8 claims. Assigned to Victor Chemical Works. [Cl. 117-136.]

Currivan, John F. Integral cartons for the protection of fragile articles. U. S. patent 2,841,320. Filed Sept. 9, 1953. 5 claims. [Cl. 229-39.] An integral inner element in a one-piece paperboard carton protects the article packaged and isolates it from the carton walls.

De La Fuente, Murray. Packaging means for small articles. U. S. patent 2,841,282. Filed July 26, 1956. 4 claims. Assigned to Aerovox Corp. [Cl. 206-80.] Capacitors, etc., are packaged in a transparent envelope attached to a severable flap of a paperboard backing card.

Denison, William E. Machine and method for making containers for comestibles. U. S. patent 2,841,055. Filed June 20, 1955. 18 claims. Assigned to Ruby Whitney. [Cl. 93-1.] Dishlike containers for bread are formed of creped paper.

Dohmen, Heinrich. Process for the manufacture of briquets, particularly fuel briquets. U. S. patent 2,841,478. Filed Jan. 17, 1955. 8 claims. Assigned to N. V. Eldeka. [Cl. 44-15.] Carboxymethylcellulose and other cellulose ethers are used.

Ebert, Edward A. Habitat or matrix for live bait type creatures as worms, crayfish, or helgramites. U. S. patent 2,841,113. Filed Aug. 17, 1956. 1 claim. [Cl. 119-1.] The matrix is formed of cellulose sponge containing individual protruding fibers.

Fischer, Paul E. Rotary dewaxer for coated paper or cardboard blands. U. S. patent 2,841,112. Filed March 3, 1955. 5 claims. Assigned to E. G. Staude Mfg. Co., Inc. [Cl. 118-11.]

Forrer, Homer W. Paperboard wrapper having an upstanding handle. U. S. patent 2,841,279. Filed Feb. 20, 1957. 9 claims. Assigned to Mead-Atlanta Paper Co. [Cl. 206-65.] A can carrier is provided with a flat-folding handle.

Frasch, Mary E. Folding box construction. U. S. patent 2,841,318. Filed June 7, 1956. 1 claim. [Cl. 229-33.] The hinged cover of a flap box carries extensions which hold the box contents in place when the box cover is closed.

Fulghum, Oscar T. Log-debarking machine. U. S. patent 2,841,195. Filed Oct. 25, 1956. 3 claims. [Cl. 144-208.]

Goldman, Joshua H. Method of manufacturing a nonwoven fibrous sheet. U. S. patent 2,841,204. Filed Feb. 5, 1953. 5 claims. [Cl. 154-33.] A dry method of felting paper and pulp fibers and the like is described.

Gray, Kenneth R., Crosby, Hartzell L., and Steinberg, John C. Recovery of chemicals from smelt solutions. U. S. patent 2,841,561. Filed March 12, 1954. 7 claims. Assigned to Rayonier Inc. [Cl. 252-183.] The process is of particular use in a two-stage acid-alkaline digestion system.

Grossi, Frank X. Colored food product and method of making the same. U. S. patent 2,841,499. Filed March 3, 1955. 2 claims. Assigned to Union Starch & Refining Co. [Cl. 99-148.] Sodium carboxymethylcellulose is used.

Hayes, Mary B. Process of producing all skin rayon. U. S. patent 2,841,463. Filed June 29, 1955. 5 claims. Assigned to American Viscose Corp. [Cl. 18-54.] The viscose additive is a phenylenediamine.

Hincher, Lee D. Paper edge flaring machine. U. S. patent 2,841,056. Filed Sept. 18, 1953. 3 claims. [Cl. 93-36.] An improved setup box-forming machine is described.

Hirschy, Harlan W. Apparatus for forming a multiple web product. U. S. patent 2,841,202. Filed Dec. 17, 1954. 6 claims. Assigned to Kimberly-Clark Corp. [Cl. 154-1.7.] A laminated web having the same strength in transverse and longitudinal directions is formed.

Howard, Edward J., and Cranford, William B. Manufacture of alkali cellulose and pulp sheets therefor. U. S. patent 2,841,580. Filed Oct. 11, 1955. 4 claims. Assigned to Canadian International Paper Co. [Cl. 260-233.] The pulp sheets are laminated with an alkali-soluble cellulose ether.

Jenney, Ray S., Fetherston, Robert T., and Miller, Glen R. Device for orienting articles conveyed forwardly to a packaging machine. U. S. patent 2,841,269. Filed Dec. 30, 1955. 5 claims. Assigned to Kellogg Co. [Cl. 198-30.] Articles being conveyed to a cartoning point are reoriented after a change in movement direction.

La Bombard, Leon E. Individual presser roll unit. U. S. patent 2,841,270. Filed March 21, 1956. 6 claims. Assigned to International Paper Box Machine Co. [Cl. 198-165.] Improved conveying means are provided for forwarding paperboard blanks in a box blank folding machine.

Lefebvre, Frank J. Locked package display holder. U. S. patent 2,841,281. Filed Oct. 26, 1956. 6 claims. Assigned to Ivers-Lee Co. [Cl. 20-79.] Means are provided to hold a paperboard-headed cellophane packet to a paperboard display panel.

Lewis, Stephen J. Machines for inserting filled containers into cases. U. S. patent 2,840,965. Filed July 23, 1954. 17 claims. [Cl. 53-160.] The machine cartons filled paper milk containers.

Lytton, Marion R. Production of all skin rayon. U. S. patent 2,841,462. Filed June 29, 1955. 6 claims. Assigned to American Viscose Corp. [Cl. 18-54.] This is similar to U. S. patent 2,847,272 (Aug. 12, 1958) the additive being the ethylene oxide adduct of *p,p'*-diphenol.

Macholl, James F., and Patterson, Kenneth. Electrolyte additive for storage batteries. U. S. patent 2,841,632. Filed July 1, 1958. 5 claims. Assigned to Gould-National Batteries, Inc. [Cl. 136-153.] Cobalt sulphate and silver sulphate are added to prolong the life of the cellulose fiber separator plates used.

McLaurin, Dunbar S. Discardable hygienic kit. U. S. patent 2,841,147. Filed Nov. 17, 1954. 2 claims. [Cl. 128-275.] A paper sheet subdivides into elements useful for sexual hygiene purposes.

Muller, Kurt, and Tonniges, Heinz. Fiber molding apparatus. U. S. patent 2,841,054. Filed Aug. 17, 1956. 21 claims. Assigned to Deutsche Fibrit G. m. b. H. [Cl. 92-54.] An accretion mold for forming molded pulp articles is provided.

Norton, Robert K. Control for sheet feeder. U. S. patent 2,841,392. Filed Oct. 20, 1955. 6 claims. Assigned to Harris-Intertype Corp. [Cl. 271-27.] When an irregularity occurs in a mechanism feeding sheets to a printing press, suction to the sheet forwarding and gripping means is interrupted.

Norton, Robert K. Sheet feeding mechanism. U. S. patent 2,841,391. Filed April 7, 1954. 9 claims. Assigned to Harris-Intertype Corp. [Cl. 271-12.] The mechanism feeds sheets to a printing press while registering them, the speed of the feeding mechanism being varied in each cycle.

Pace, Leo C. Container for shoes and the like. U. S. reissue patent 24,495. Filed Jan. 27, 1958. 9 claims. [Cl. 229-52.]

An extensible string handle which also serves to lock carton body and telescoping cover is provided.

Paige, Richard E. Windshield shipping carton assembly. U. S. patent 2,841,277. Filed May 3, 1956. 12 claims. [Cl. 206-62.]

Pelletier, Louis G. Cigarettes. U. S. patent 2,841,153. Filed June 16, 1955. 2 claims. [Cl. 131-9.] A cylindrical paper venting tip is provided.

Reed, Russell H. Method and apparatus for depositing fibrous elements in the manufacture of fibrous structures. U. S. patent 2,840,865. Filed Oct. 22, 1954. 12 claims. Assigned to Changewood Corp. [Cl. 19-155.] Mats for particle board are formed to have improved surface uniformity.

Rodgers, John C., and Kiwi, Walter. Partition assembling machines. U. S. patent 2,841,057. Filed Aug. 29, 1955. 9 claims. Assigned to Huntingdon Industries Inc. [Cl. 93-38.]

Rueckert, Dean E. Protective composition. U. S. patent 2,841,506. Filed June 15, 1953. 16 claims. Assigned to Swift & Co. [Cl. 117-76.] Adhesive-treated plastic-coated tissue paper is claimed as a packaging material.

Rutishauser, Edgar. Paper-clamping device for rotary duplicating machines. U. S. patent 2,841,393. Filed Sept. 3, 1954. 7 claims. [Cl. 271-61.]

Schmidt, Jacques, and Meyer, Pierre-F. A. Process for manufacturing cellulose wool and resulting products thereof. U. S. patent 2,841,529. Filed Feb. 10, 1953. 10 claims. Assigned to Société dite: Papeteries de la Robertsau, Société Anonyme. [Cl. 167-84.] Chlorophyll is deposited on the fibers of the furnish, forming an odor-resistant product.

Schwimmer, David, Schwimmer, Morton, and Sierer, George A. Combination dispensing and disposal device. U. S. patent 2,841,275. Filed June 16, 1955. 3 claims. [Cl. 206-57.] A paperboard dispensing container for paper tissues includes a compartment for storing the used and soiled tissues.

Schwimmer, David, Schwimmer, Morton, and Sierer, George A. Combination dispensing and disposal device. U. S. patent 2,841,276. Filed Sept. 13, 1955. 1 claim. [Cl. 206-57.] This is similar to U. S. patent 2,841,275 (July 1, 1958).

Scott, John J. Paint brush wrapper. U. S. patent 2,841,273. Filed Oct. 11, 1955. 4 claims. Assigned to United States Envelope Co. [Cl. 206-15.1.] A paperboard wrapper locks about the brush.

Stobb, Anton R. Collector for flexible sheets. U. S. patent 2,841,394. Filed March 23, 1955. 9 claims. Assigned to Western Printing & Lithographing Co. [Cl. 271-87.] Printed signatures are received from the press in overlapped or echeloned relation and are aligned and stacked.

Stremke, William F., Stremke, William F., Jr., and Pazderski, Roman R. Wrapping method and apparatus. U. S. patent 2,840,962. Filed June 1, 1954. 9 claims. [Cl. 53-31.] Food products are wrapped and heat-sealed in paper, cellophane, or the like.

Villefroy, Jacques A., and Saxton, William R. Depolymerization of cellulose in alkaline medium. U. S. patent 2,841,579. Filed April 15, 1954. 20 claims. Assigned to Canadian International Paper Co. [Cl. 260-233.] In aging viscose with a metallic oxidation catalyst, an agent is added to prevent precipitation of the catalyst.

Vitoux, Paul. Packaging devices. U. S. patent 2,841,306. Filed March 30, 1954. 4 claims. Assigned to Société dite: Comptoir Linier. [Cl. 220-7.] A collapsible metal rod-reinforced assembly of paper panels forms a shipping carton for bakery goods.

Walsh, Paul R., and Mohr, George D. Advancing mechanism. U. S. patent 2,841,298. Filed Nov. 19, 1956. 5 claims. Assigned to Clear Fir Products Co. Inc. [Cl. 214-16.6.] Roller means are provided to move sheets of hardboard from the forming press.

Weathers, Elbert J. Matchbook. U. S. patent 2,841,274. Filed Dec. 3, 1956. 1 claim. [Cl. 206-29.] The match card is a radially slotted disk, with the match heads on the periphery of the disk.

Werner, Arnold J. Automatic taping mechanisms. U. S. patent 2,841,305. Filed March 5, 1956. 2 claims. Assigned to Wagner Iron Works. [Cl. 216-29.] The apparatus applies tape to seal the closure flaps of paperboard cartons.

White, Roger L., Miller, Richard C., and Young, Lewis E. Shipping container for produce. U. S. patent 2,841,319. Filed July 18, 1955. 3 claims. Assigned to Lawrence Paper Co. [Cl. 229-37.] The ventilated double-walled paperboard produce shipper is constructed so that ventilation is maintained when the cartons are stacked.

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Albert, Marcel O. Container. U. S. patent 2,842,301. Filed Aug. 2, 1955. 1 claim. [Cl. 229-1.5.] A multi-ply paper cup is provided with an aluminum liner.

Anderson, Joseph M., and Porter, Floyd B., Jr., Continuous manufacture of liquid rosin size. U. S. patent 2,842,453. Filed May 6, 1955. 8 claims. Assigned to American Cyanamid Co. [Cl. 106-238.]

Brian, Percy W., Radley, Margaret E., Curtis, Philip J., and Elson, George W. Gibberellic acid compounds and preparation and use thereof. U. S. patent 2,842,051. Filed June 27, 1955. 11 claims. Assigned to Imperial Chemical Industries Ltd. [Cl. 71-2.5.]

Christensen, Grover N. Protective binder for cardboard mounted photographic transparencies. U. S. patent 2,841,903. Filed March 16, 1956. 11 claims. [Cl. 40-152.]

Dereich, John E. Sodium silicate adhesive. U. S. patent 2,842,448. Filed May 13, 1953. 5 claims. Assigned to Diamond Alkali Co. [Cl. 106-82.] The adhesive is nonadherent to the heated metal surfaces of converting machines.

Doughty, Joseph B. Nitrogen containing lignins and method of making same. U. S. patent 2,842,534. Filed Feb. 20, 1956. 1 claim. Assigned to West Virginia Pulp and Paper Co. (Cl. 260-124.] Lignin is reacted with ethyleneimine to form a fertilizer.

Dunning, Robert M., and Zastrow, Harold G. Bottle carriers. U. S. patent 2,842,288. Filed Aug. 10, 1951. 4 claims. Assigned to Waldorf Paper Products Co. [Cl. 220-113.]

Freyermuth, Harlan B., and Williams, William W. Optical bleaching compositions. U. S. patent 2,842,501. Filed Dec. 30, 1955. 6 claims. Assigned to General Aniline & Film Corp. [Cl. 252-117.]

Gaines, George L., Jr., Mica paper. U. S. patent 2,842,183. Filed Sept. 24, 1956. 4 claims. Assigned to General Electric Co. [Cl. 154-2.6.] Aqueous barium chloride or acetate is applied to the mica before it is processed into sheets.

Giraudet, Pierre. Supporting box for articles, method and means for its manufacture. U. S. patent 2,842,263. Filed Nov. 1, 1954. 2 claims. Assigned to Satem S. A. Anonyme: Societe d'Application Technique d'Emballages Modernes. [Cl. 206-65.] An open-bottom, open-top paperboard container for the protective packaging of light bulbs, eggs, or other fragile articles is described.

Grummitt, Oliver J., and Arters, Albert A. Aqueous vehicles for forming water-resistant films. U. S. patent 2,842,451. Filed Dec. 23, 1954. 14 claims. Assigned to Sherwin-Williams Co. [Cl. 106-194.] A composition is provided for coating paper to impart resistance to water, soap, and ammonia.

Heyman, Albert A. Bottom expander. U. S. patent 2,842,033. Filed June 14, 1956. 5 claims. Assigned to Maryland Cup Co. [Cl. 93-36.5.] In a machine for forming frustoconical paper cups, means are provided for forming the bottom-side wall joint.

Hoeppner, Arthur D. Closures for flexible walled containers. U. S. patent 2,842,179. Filed May 7, 1956. 5 claims. Assigned to Bemis Bro. Bag Co. [Cl. 150-7.] A flat paper bag, closed top and bottom after filling, has closures which hold the filled bag in rectangular configuration.

Hornbostel, Lloyd. Paper machine dryer drive mechanism. U. S. patent 2,841,882. Filed Sept. 30, 1955. 5 claims. Assigned to Beloit Iron Works. [Cl. 34-121.]

Jablon, Theodore M. Slide mountings. U. S. patent 2,841,904. Filed Jan. 29, 1957. 6 claims. [Cl, 40-152.] A mounting element is provided for paperboard-framed photo transparencies.

Journeay, Glen E. Cyanoethyl ethers. U. S. patent 2,842,541. Filed July 27, 1954. 7 claims. Assigned to Monsanto Chemical Co. [Cl. 260-231.] Cellulose, starch, and the like are cyanoethylated.

Koenecke, Donald F., and Brady, Harold J. Cellulose nitrate-liquid polymer oil compositions. U. S. patent 2,842,452. Filed Nov. 22, 1955. 2 claims. Assigned to Esso Research and Engineering Co. [Cl. 106-195.]

Krueger, Alfred P. Bag-tying machine. U. S. patent 2,841,935. Filed March 12, 1956. 12 claims. Assigned to Derby Sealers, Inc. [Cl. 53-135.] Adhesive tape is wrapped about the gathered neck of a bag.

Larkin, James F. Counting and packaging machine. U. S. patent 2,842,035. Filed Aug. 13, 1954. 1 chaim. [Cl. 93-93.] Newspapers are counted, stacked, and bundled.

Leavens, William B., Jr. Apparatus for loading the supply magazine of a packaging machine with collapsed cartons. U. S. patent 2,842,363. Filed Oct. 11, 1956. 7 claims. [Cl. 271-61.]

Lighter, Stephen. Container. U. S. patent 2,842,261. Filed June 22, 1951. 1 claim. [Cl. 206-45.31.] A paperboard container for a number of smaller boxes comprises a four-sided structure which retains the smaller boxes in a manner suitable for display.

Mojonnier, Albert B. Carton filling apparatus. U. S. patent 2,841,936. Filed Sept. 23, 1954. 19 claims. [Cl. 53-266.] Milk cartons are moved through a filling machine in side-abutting relation.

Mossor, George W. Sleeving apparatus for valved paper bags.

U. S. patent 2,842,032. Filed Sept. 19, 1956. 32 claims. Assigned to Hudson Pulp & Paper Corp. [Cl. 93-8.]

Platt, Samuel. Setup box. U. S. patent 2,842,303. Filed Feb. 14, 1955. 2 claims. Assigned to United Paper Box Co. [Cl. 229-30.] A setup paperboard box is provided with a hinged cover capable of holding any open position in which it is placed.

Pomper, Anthony W. Reverse roll coating machine with blade support for web. U. S. patent 2,842,092. Filed March 2, 1955, 9 claims. Assigned to John Waldron Corp. [Cl. 118-248.]

Ringler, William A. Shipping and carrying cartons. U. S. patent 2,842,304. Filed July 7, 1954. 10 claims. Assigned to Diamond Match Co. [Cl. 229-51.] Improved cover and handle means are provided in a shipping case for cans, jars, and the like.

Robertson, James A. Aqueous fireproofing composition of sodium oxyfluoborate and phenol formaldehyde, method of treating paper therewith and article prepared therefrom. U. S. patent 2,842,510. Filed Aug. 15, 1955. 7 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 260-29.3.]

Ryder, Fred A. Pouring spout carton. U. S. patent 2, 842,302. Filed April 19, 1956. 5 claims. Assigned to Chicago Carton Co. [Cl. 229-17.]

Short, Oliver A. Ceramic color compositions. U. S. patent 2,842,454. Filed March 2, 1956. 6 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 106-268.] Phosphorated tall oil is used.

Sterk, Boris J. Polyethylene-wax compositions and method for preparing same. U. S. patent 2,842,508. Filed Aug. 23, 1957. 12 claims. Assigned to Socony Mobil Oil Co., Inc. [Cl. 260-28.5.] The storage-stable compositions are useful in coating milk cartons.

Tolf, Ingvar L. Machine for applying tear tape to carton blanks. U. S. patent 2,842,034. Filed Feb. 27, 1953. 12 claims. Assigned to General Foods Corp. [Cl. 93-36.9.]

Vogt, Clarence W. Tape dispensing and cutting device. U. S. patent 2,842,201. Filed June 30, 1955. 10 claims. [Cl. 164-84.5.]

Wills, John R., and Jane, Clarence W. Carton folding and closing means. U. S. patent 2,841,942. Filed Feb. 19, 1954. 10 claims. Assigned to Ex-Cell-O Corp. (Cl. 53-375.] A machine for filling gable-top paperboard milk cartons is provided with means to fold and close the mouths of the cartons after filling.

Wright, Ansel J. Master card for reproduction by the spirit transfer process. U. S. patent 2,842,050. Filed June 13, 1955. 2 claims. Assigned to Master Addresser Co. [Cl. 101-149.4.]

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Altenburg, William M., and Foote, James E. Molded pulp pear tray. U. S. patent 2,843,496. Filed July 26, 1956. 17 claims. Assigned to Diamond Gardner Corp. [Cl. 99-171.]

Bandy, Edgar M. Holder for pouring containers. U. S. patent 2,843,302. Filed May 10, 1954. 1 claim. [Cl. 224-45.] The holder supports a gable-top paperboard mild carton during use.

Battersby, James E. Sheet cutting and laying machines or apparatus. U. S. patent 2,843,377. Filed Nov. 14, 1955. 15 claims. Assigned to Masson Scott & Co. Ltd. [Cl. 271-76.] Sheets cut from a web are arranged in an overlapped stream.

Bletzinger, John C., Day, Winterton U., and Rothe, Richard E. Sanitary napkin. U. S. patent 2,843,125. Filed Oct. 5, 1955. 5 claims. Assigned to Kimberly-Clark Corp. [Cl. 128-290.]

Boeye, Paul F. Outboard motor package. U. S. patent 2,843,258. Filed Oct. 8, 1956. 13 claims. [Cl. 206-46.] A wood-reinforced corrugated container is provided.

Burger, Martin. Egg carton setup equipment. U. S. patent 2,843,026. Filed July 27, 1954. 7 claims. Assigned to Diamond Gardner Corp. [Cl. 93-37.]

Carkhuff, Le Roy F., and Fahey, Richard J. Carton closing machine. U. S. patent 2,842,920. Filed Sept. 24, 1954. 10 claims. Assigned to Diamond Gardner Corp. [Cl. 53-137.] The machine closes molded pulp egg cartons of the type having integral snap-locking means.

Collins, Harry F., Jr. Cartons. U. S. patent 2,843,257. Filed Jan. 13, 1956. 2 claims. Assigned to Northwestern Corrugated Box Co. [Cl. 206-46.] Each of three pieces of a thermostatic control are separately contained and supported by a one-piece carton.

Faeber, Harry W. Stacking apparatus. U. S. patent 2, 843,378. Filed May 22, 1956. 6 claims. Assigned to Time, Inc. [Cl. 271-87.] Printed, slit, cut, and folded signatures are delivered on a conveyor in horizontal position and stacked in vertical position.

Folwell, John H., and Eaton, Wentworth C. Paper mount for transparencies. U. S. patent 2,842,883. Filed May 10, 1956. 4 claims. Assigned to Eastman Kodak Co. [Cl. 40-158.]

Goltz, Joseph. Box construction. U. S. patent 2,843,307. Filed Dec. 21, 1955. 7 claims. [Cl. 229-34.] A collapsible box for furs, furniture, and other items sets up without the use of nonintegral locking or securing means.

Harlan, Warren H. Machine for forming and feeding coupons. U. S. patent 2,842,911. Filed Aug. 28, 1953. 12 claims. Assigned to The Procter & Gamble Co. [Cl. 53-57.]

Holden, Herbert. Paper-making machines. U. S. patent 2,843,025. Filed March 31, 1954. 2 claims. Assigned to Beloit Iron Works. [Cl. 92-49.] A vacuum transfer arrangement is described.

Hopkins, Alfred J. Shipment data holder. U. S. patent 2,843,310. Filed Jan. 10, 1956. 2 claims. Assigned to Gaw-O' Hara Envelope Co. [Cl. 229-72.] A paper device is provided for attaching shipping data to the outer wall of a container.

Howatt, George F. Banding machine. U. S. patent 2, 842,915. Filed Oct. 31, 1955. 24 claims. Assigned to New England Envelope Mfg. Co. [Cl. 53-74.] A paper band is adhered about a packet of envelopes.

Lunn, Edward O. Rotary-ring debarker having cable-biased springy-blade scrapers. U. S. patent 2,843,168. Filed April 22, 1957. 11 claims. [Cl. 144-208.]

Metzger, Henry L. Commodity wrapper and package. U. S. patent 2,843,259. Filed Nov. 22, 1954. 2 claims. Assigned to Fort Orange Paper Co. [Cl. 206-47.] A paper packaging sleeve is provided for a number of ice cream cups.

Myers, Chester G. Thick-sided box. U. S. patent 2,843, 305. Filed Sept. 30, 1955. 4 claims. [Cl. 229-30.] This is similar to U. S. patent 2,943,306. (July 15, 1958.).

Myers, Chester G., Kuhlman, Carl E., and Beckner, Martin M. Box. U. S. patent 2,843,306. Filed Sept. 2, 1955. 4 claims. Assigned to Autokraft Box Corp. [Cl. 229-34.] A multiwall paperboard cigar box is provided.

Paige, Richard E. Double-walled container. U. S. patent 2,843,308. Filed May 16, 1956. 1 claim. [Cl. 229-37.] The open-top single blank box is for packaging fruit.

Piersol, Jay L. Method of making rubber-bound fibrous products and the like. U. S. patent 2,843,479. Filed March 16, 1955. 15 claims. Assigned to Armstrong Cork Co. [Cl. 92-21.] A method of depositing a synthetic rubber latex upon the fibers of a papermaking furnish is described.

Politzer, Alfred. Method of producing artificial sponges. U. S. patent 2,842,799. Filed March 3, 1955. 7 claims. [Cl. 18-48.] Fiber-reinforced regenerated cellulose sponge is formed.

Qveflander, Tor G. Method of feeding wood into continuously operating grinders for the production of wood pulp. U. S. patent 2,843,278. Filed July 20, 1955. 4 claims. [Cl. 214-152.]

Reifers, Richard F. Molded pulp carton lock. U. S. patent 2,843,304. Filed Nov. 20, 1952. 5 claims. Assigned to Diamond Gardner Corp. [Cl. 229-29.] Integral locking means are provided for the hinged cover of an egg carton.

Riedel, Frederick H. Method and apparatus for treating impregnated fiber webs. U. S. patent 2,843,505. Filed Feb. 4, 1954. 18 claims. Assigned to Wood Conversion Co. [Cl. 117-102.] An improved roll construction is provided in rolls for pressing a fiber web impregnated with latex.

Salo, Martin, and Clarke, Gerard J. Corrosion resisting coatings. U. S. patent 2,843,503. Filed Jan. 8, 1954. 7 claims. Assigned to Eastman Kodak Co. [Cl. 117-85.] Cellulose acetate butyrate is employed in a corrosion-resistant coating for steel.

Sarring, Ernest J., and Mayer, Theodore W. Integrated imprinting and labeling machine. U. S. patent 2,843,283. Filed Jan. 3, 1957. 27 claims. Assigned to R. R. Donnelley & Sons Co. [Cl. 216-1.] Books are imprinted, labeled, and delivered to a packing station.

Seal, Henry R. Dental polishing disk. U. S. patent 2, 842,844. Filed March 22, 1956. 7 claims. [Cl. 32-59.] The disk is made of abrasive paper.

Sherron, Emmitt B. Self-propelled logging machine for cutting and processing trees. U. S. patent 2,843,165. Filed March 29, 1955. 17 claims. [Cl. 143-43.]

Simon, Walter E. A. Thermoplastic condensation product of benzylated wood with acetophenone and method of preparing same. U. S. patent 2,843,578. Filed Nov. 12, 1953. 2 claims. Assigned 50% to Bernard E. Smith. [Cl. 260-124.]

Stuckey, Benjamin N., and Gearhart, William M. Wax coatings containing synergistic antioxidants. U. S. patent 2,843,497. Filed Feb. 23, 1955. 2 claims. Assigned to Eastman Kodak Co. [Cl. 106-287.] The compositions are used to coat paper and board for use in packaging.

Voris, Robert S. Preparation of finely-divided cellulose derivative compositions. U. S. patent 2,843,583. Filed March 3, 1955. 6 claims. Assigned to Hercules Powder Co. [Cl. 260-223.]

Voris, Robert S. Preparation of finely-divided cellulose

derivatives. U. S. patent 2,843,582. Filed April 8, 1954. 5 claims. Assigned to Hercules Powder Co. [Cl. 260-233.]

Wheeler, Oscar G. Tamper-proof shipping bag. U. S. patent 2,843,309. Filed Feb. 2, 1956. 1 claim. Assigned to H. J. Dowd Co. Inc. [Cl. 229-62.] An improved closure for a heavy paper mail bag is provided.

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Bernstein, Russell W., and Block, Aleck. Abrasive wheel and replaceable abrasive unit therefor. U. S. patent 2,843,980. Filed April 8, 1957. 11 claims. Assigned to Merit Products Inc. [Cl. 51-193.5.]

Block, Aleck. Abrasive drum. U. S. patent 2,843,981. Filed March 27, 1957. 10 claims. Assigned to Merit Products, Inc. [Cl. 51-193.7.]

Boardway, Johanna C. Package containing article with delicate surface. U. S. patent 2,844,471. Filed April 12, 1957. 2 claims. [Cl. 99-171.] A frosted cake is packaged on a paper plate with transparent overwrap spaced from the frosted surface.

Borgstrom, Bruce W. Disposable door mats. U. S. patent 2,843,868. Filed March 19, 1956. 2 claims. [Cl. 15-215.] Suitably coated paper is employed.

Buhrke, Fred W. Box forming machine. U. S. patent 2,844,077. Filed June 27, 1956. 11 claims. Assigned to Fraser Label Co. [Cl. 93-51.] The machine folds and heat seals flat blanks to form open-top boxes.

Capitani, Francesco De. Cigarette with igniter element and method of making such cigarette. U. S. patent 2,844,152. Filed March 15, 1954. 7 claims. [Cl. 131-7.] Igniter elements are adhesively applied to a paper web before the web is formed into cigarettes.

Davis, John S., and Bochow, Walter. Machine for forming and applying cord handles to a paper bag web. U. S. patent 2,844,075. Filed Dec. 8, 1954. 19 claims. Assigned to Equitable Paper Bag Co., Inc. [Cl. 93-8.]

Dexter, Robert G., and Willett, John A. Sheet collating machine. U. S. patent 2,844,368. Filed Oct. 6, 1954. 15 claims. Assigned to Cummington Corp. [Cl. 270-58.]

Ehrenfried, John F., and Von Gunten, Leo J. Method of packaging bacon strips. U. S. patent 2,844,472. Filed June 14, 1955. 2 claims. Assigned to The Goodyear Tire & Rubber Co. [Cl. 99-174.] A windowed paperboard wrapper partially overwrapped with pliofilm is described.

Engelstein, Stanley. Record card and film holder assembly. U. S. patent 2,843,955. Filed April 5, 1957. 6 claims. Assigned to Enbee Transparent Specialty Co., Inc. [Cl. 40-158.] A paperboard filing assembly for microfilm is provided.

Greminger, George K., Jr. Hydraulic cement compositions for wells. U. S. patent 2,844,480. Filed May 31, 1956. 4 claims. Assigned to The Dow Chemical Co. [Cl. 106-93.] Carboxymethylcellulose is used.

Gruber, Leonard J., and Fessenden, Marvin S. Carton for attachment to a container. U. S. patent 2,844,245. Filed July 8, 1957. 5 claims. Assigned to The Central Carton Co. [Cl. 206-47.] The carton, for a merchandising premium, is designed to be attached over the top of a jar lid.

Guyer, Reynolds. Sliced meat package. U. S. patent 2,844,300. Filed April 2, 1954. 1 claim. Assigned to Waldorf Paper Products Co. [Cl. 229-87.] The paperboard wrapper blanks are designed to permit laying them out on the stock material without waste.

Haxo, Henry E., Jr., and Mills, George S. Method for the incorporation of lignin into synthetic rubber. U. S. patent 2,844,548. Filed July 28, 1954. 6 claims. Assigned to United States Rubber Co. [Cl. 260-17.5.]

Hoffmeister, Hans G. Carton forming apparatus. U. S. patent 2,844,076. Filed July 15, 1953. 23 claims. Assigned to Food Machinery and Chemical Corp. [Cl. 93-15]. An improved plunger-and-die forming apparatus uses a die which has no movable parts thereon.

Holmes, Raynor M. Collapsible carton. U. S. patent 2,844,297. Filed June 23, 1955. 5 claims. Assigned to Bloomer Bros. Co. [Cl. 229-41.] An ice cream carton of the automatic bottom type is designed to retain its erected shape even when opened for use of the contents.

Hubbard, James K. Paper-like pellicle and method for producing same. U. S. patent 2,844,491. Filed April 29, 1955. 6 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 117-65.] A bonded water-laid web of nylon fibers is formed on conventional paper machinery.

Kessler, David E., and Hauf, Theodore F. Beverage cooler carton. U. S. patent 2,844,299. Filed June 17, 1957. 5 claims. Assigned to Pabst Brewing Co. [Cl. 229-52.] A paperboard beer can case may be converted to provide an ice compartment.

Kingsley, Lewis A. Foil container. U. S. patent 2,844,246. Filed Sept. 20, 1956. 1 claim. [Cl. 206-52.] A nonjamming metal-end tubular paperboard dispensing container is provided for rolls of foil of a type used in hot stamping.

Lambert, Harry E. Egg packing material. U. S. patent 2,844,268. Filed Jan. 17, 1952. 3 claims. Assigned to Central Fibre Products Co. [Cl. 217-26.5.] A crush-resistant molded pulp egg crate filler is provided.

Lang, Maurice, and Terjesen, Tellef A. Wafer-type cells for dry batteries and method for making same. U. S. patent 2,844,641. Filed Oct. 12, 1954. 4 claims. Assigned to United States Electric Mfg. Corp. [Cl. 136-111.] Electrolyte-coated paper is used.

Lawton, Thomas O., and Wilson, Filmore G. Method for chemically treating wood particles. U. S. patent 2,844,464. Filed Dec. 7, 1954. 5 claims. [Cl. 92-7.] A pulping method permits digestion under pressure without requiring that the digester be built of heavy materials and without requiring other pressure equipment.

Liebenow, Julius G., and Liebenow, Gilbert I. Stripper mechanism. U. S. patent 2,844,372. Filed Sept. 28, 1955. 1 claim. [Cl. 271-63.] Improved paperboard sheet forwarding means are provided in a Miehle printing press which has been converted to diecutting.

Maskey, Donald F. Adhesive composition. U. S. patent 2,844,482. Filed Sept. 12, 1955. 6 claims. Assigned to The Buckeye Cellulose Corp. [Cl. 106-154.] The composition is of use in laminating paper and veneer sheets and in making wound paper tubing.

Miller, Carl S., and Kuhrmeyer, Carl A. Reflex thermoprinting. U. S. patent 2,844,733. Filed April 2, 1956. 4 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 250-65.]

Painter, Claude D. Cellular bottle carrier. U. S. patent 2,844,282. Filed Sept. 11, 1956. 1 claim. Assigned to Karry-All, Inc. [Cl. 220-115.]

Paxton, Homer W. Method of bonding elastomers to other materials and adhesive compositions used therefor. U. S. patent 2,844,502. Filed Aug. 31, 1954. 13 claims. Assigned to United States Rubber Co. [Cl. 154-139.] An adhesive composition for use in laminating paper is provided.

Provost, Raoul L. Method for the incorporation of lignin into synthetic rubber. U. S. patent 2,844,549. Filed July 28, 1954. 6 claims. Assigned to United States Rubber Co. [Cl. 260-17.5.]

Ringler, William A. Multicelled article carriers. U. S. patent 2,844,280. Filed Sept. 21, 1954. 5 claims. Assigned to Diamond Gardner Corp. [Cl. 220-113.] This is similar to U. S. patent 2,844,281 (July 22, 1958).

Ringler, William A. Multicelled article carriers. U. S. patent 2,844,881. Filed Sept. 21, 1954. 9 claims. Assigned to Diamond Gardner Corp. [Cl. 220-113.] The construction of a bottle carrier is such that any desired number of cells may be formed while retaining the basic principles of the carrier design.

Rowlands, Tom, and Hubbard, Henry J. Sheet feeding devices of the reciprocating tooth type. U. S. patent 2,844,371. Filed May 2, 1955. 1 claim. Assigned to Molins Machine Co., Ltd. [Cl. 271-44.]

Seiferth, Oscar E., and Royston, Calvin T. Sliced food package. U. S. patent 2,844,473. Filed July 6, 1955. 12 claims. Assigned to Oscar Mayer & Co., Inc. [Cl. 99-174.] A collapsible paperboard container with hinged windowed lid is provided for a sliced slab of bacon.

Sherman, Whitney D., and Ahlmeyer, Heinz. Folding machine for the manufacture of paperboard boxes and the like. U. S. patent 2,844,078. Filed July 13, 1953. 4 claims. Assigned to Continental Can Co., Inc. [Cl. 93-52.] The folder permits pregluing of the blank into continuous band form.

Soja, Lawrence M. Lock bottom for paperboard container. U. S. patent 2,844,296. Filed Nov. 8, 1956. 1 claim. Assigned to Stone Container Corp. [Cl. 229-39.]

Tamarin, Bernard J. Tapeless unfoldable closure for cigarette packages. U. S. patent 2,844,298. Filed Sept. 3, 1954. 5 claims. [Cl. 229-51.]

Ware, Richard N., Jr., and Cannon, Reginald. Apparatus for making paper-covered wood veneer. U. S. patent 2,844,174. Filed July 7, 1954. 11 claims. Assigned to Chicago Mill and Lumber Co. [Cl. 144-279.]

Wells, Robert H. Process for the preparation of cellulose acetate in an esterification medium of acetic acid, acetic anhydride, methylene chloride, and sulfuric acid. U. S. patent 2,844,575, Filed March 23, 1956. 2 claims. Assigned to Celanese Corp. of America. [Cl. 260-227.]

Whitecar, Alten E. Inserting apparatus. U. S. patent 2,843,972. Filed May 29, 1953. 25 claims. Assigned to Smith, Kline & French Laboratories. [Cl. 53-55.] The machine heat-seals a cellophane packet of tablets within a matchbooklike cover sheet.

Whitney, Anthony M. Corner construction for a chick box. U. S. patent 2,844,293. Filed Feb. 17, 1955. 2 claims. Assigned to New England Wooden Ware Corp. [Cl. 229-6.]

Williams, Alford A. Chick carton. U. S. patent 2,844,294. Filed Dec. 12. 1955. 8 claims. Assigned to Old Dominion Box Co. [Cl. 229-6.] The carton has reinforcing and partitioning members and means permitting stacking of the cartons without cutting off ventilation.

Williams, David J. Apparatus for indicating and/or recording the structure of paper. U. S. patent 2,844,068. Filed Sept. 20, 1955. 13 claims. Assigned to Australian Paper Mfrs. Ltd. [Cl. 88-14.] The optical density of a traveling web of paper is measured continuously as the web is formed on the paper machine.

Williams, Richard H. Boxes. U. S. patent 2,844,295. Filed Jan. 31, 1955. 4 claims. Assigned to Northwestern Corrugated Box Co. [Cl. 229-33.] An L-shaped paperboard box is designed to provide reinforcement at the crotch of the L.

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Alt, Edward E., Jr., and Davis, Robert J. Preparation of dustless starch. U. S. patent 2,845,367. Filed Aug. 1, 1956. 2 claims. Assigned to Corn Products Refining Co. [Cl. 127-32.] The product is of particular value as a beater additive in sizing paper.

Anderson, James K., Herrick, Franklin W., and Gray, Kenneth R. Chemical products from bark. U. S. patent 2,845,450. Filed Sept. 13, 1955. 4 claims. Assigned to Rayonier Inc. [Cl. 260-473.5.]

Byrne, Hugh J. Apparatus and method for digesting. U. S. patent 2,845,347. Filed May 13, 1953. 20 claims. [Cl. 92-7.] A digester liquor-recirculation system is provided.

Clem, Everett W. Wrapping machine. U. S. patent 2,844,928. Filed April 21, 1955. 8 claims. Assigned to Rice Barton Corp. [Cl. 53-198.] Large rolls of paper are wrapped apirally, then with a straight-wound wrapping about the roll ends.

Eisen, Harry. Display assembly. U. S. patent 2,844,901. Filed Aug. 20,1956. 13 claims. [Cl. 40-158.] The invention is concerned with a laminated paper amusement device for children.

Elling, Hugo. Method of aging a viscose solution. U. S. patent 2,845,416. Filed Sept. 4, 1953. 3 claims. Assigned to American Enka Corp. [Cl. 260-218.]

Faeber, Harry W. Signature feeding and opening mechanism. U. S. patent 2,845,264. Filed July 8, 1954. 15 claims. Assigned to Time, Inc. [Cl. 270-54.]

Finke, Arno. Bag. U. S. patent 2,845,214. Filed July 14, 1954. 4 claims. Assigned to Firma Windmöller & Hölscher. [Cl. 229-62.5.] A multi-ply valve bag having a block shape when filled is provided.

Fischer, John P. Container for bulk package parts. U. S. patent 2,845,210. Filed May 22, 1953. 11 claims. Assigned to River Raisin Paper Co. [Cl. 229-14.] A high-strength telescoping-cover carton for bulk heavy goods is described.

Fredrickson, Ralph E. C. Dextrinization process. U. S. patent 2,845,368. Filed May 27, 1954. 16 claims. Assigned to A. E. Staley Mfg. Co. [Cl. 127-38.] A rapid method for dextrinizing starch involves heat-conversion of the powdered raw material in a fluidized bed.

Fridolph, Doris I. Matchholder. U. S. patent 2,845,172. Filed June 13, 1956. 3 claims. [Cl. 206-33.] A protective safety holder is provided for a matchbook.

Gerowin, Kibby. Protecting artificial flowers on women's outergarments. U. S. patent 2,845,212. Filed Jan. 14, 1955. 1 claim. [Cl. 229-39.] An open-top container fits over the flower during shipment of the garment.

Grettve, Karl E. L. Machine for winding web rolls. U. S. patent 2,845,231. Filed Feb. 17, 1955. 15 claims. Assigned to Lilla Edets Pappersbruke A.-B. [Cl. 242-56.]

Hauck, William E., and Layne, Harold W. Fiberboard container. U. S. patent 2,845,211. Filed Sept. 26, 1955. 1 claim. Assigned to Inland Container Corp. [Cl. 229-34.] An open-top reinforce corrugated produce box is provided.

Hempel, Herbert W. Tape dispenser. U. S. patent 2,845,266,. Filed March 26, 1956. 12 claims. Assigned to Marsh Stencil Machine Co. [Cl. 271-2.4.]

Hornbostel, Lloyd. Dryer. U. S. patent 2,844,887. Filed Feb. 8, 1957. 5 claims. Assigned to Beloit Iron Works. [Cl. 34-119.] Higher steam pressures are rendered possible in a paper machine drier section construction.

Keenan, Lloyd T. Method and apparatus for forming covered index tabs on sheets. U. S. patent 2,845,010. Filed July 6, 1955. 27 claims. [Cl. 93-1.] The tabs on paper index sheets are covered with cellulose acetate.

Kesler, Carl C., and Hjermstad, Erling T. Hydroxyalkylation of ungelatinized starches and dextrins in aqueous, water-miscible alcohols. U. S. patent 2,845,417. Filed Oct. 6, 1955. 3 claims. Assigned to Penick & Ford, Ltd., Inc. [Cl. 260-233.3.] The products are of use in paper adhesives and sizes and the like.

Kulhavy, Edward L. Sheet coding machine. U. S. patent 2,845,124. Filed July 5, 1955. 3 claims. [Cl. 164-114.] The machine codes cards by notching or the like to prepare them for use in accounting systems.

Langdon, Arthus J. Package for sterile articles. U. S. patent 2,845,173. Filed July 29, 1955. 2 claims. [Cl. 206-63.2.] The package comprises a two-piece telescoping-top glassine envelope.

Lytton, Marion R., and Mueller, George F. Method of producing viscose rayon. U. S. patent 2,845,327. Filed Nov. 3, 1954. 7 claims. Assigned to American Viscose Corp. (Cl. 18-54.] Smooth all-skin filaments are produced by adding a cycloimidine derivative to the viscose before spinning.

Maddox, John R. Viscosity controlling method. U. S. patent 2,845,361. Filed Feb. 27, 1956. 5 claims. Assigned to Armstrong Cork Co. [Cl. 106-123.] The viscosity of a limed mixture of tall oil and petroleum oil is controlled by the addition of minor amounts of wood rosin.

Miller, Robert. Photograph album leaf. U. S. patent 2,844,900. Filed March 18, 1954. 1 claim. [Cl. 40-158.]

Mills, George S. Method of coagulating resin treated lignin and a rubber latex and product obtained thereby. U. S. patent 2,845,397. Filed April 17, 1956. 12 claims. Assigned to United States Rubber Co. [Cl. 260-3.]

Milne, David T. Manufacturing of flexible sheets into casings. U. S. patent 2,845,357. Filed Oct. 6, 1954. 4 claims. Assigned to American Viscose Corp. [Cl. 99-176.] An improved process is provided for sealing a web (e.g., tissue paper impregnated with hydroxyethylcellulose) into a food-packaging casing.

Morse, Erwin E., and Hearn, Walter L. Processes for production of furfural. U. S. patent 2,845,441. Filed Nov. 16, 1955. 5 claims. Assigned to Brown Co. [Cl. 260-347.9.] The process recovers furfural from spent sulphite liquor from a hardwood cook.

Murchison, Blackwell K. Perforator device. U. S. patent 2,845,123. Filed Jan. 17, 1955. 2 claims. [Cl. 164-113.] Electric impulses from an electric typewriter cause holes to be punched in a paper tape which is to be used in typesetting.

Nelson, Iver L. Carton closing apparatus. U. S. patent 2,844,930. Filed Feb. 11, 1957. 14 claims. Assigned to Waldorf Paper Products Co. [Cl. 53-376.]

Pinckert, Carl W., and White, Raymond E. Web feed means for rotary printing press. U. S. patent 2,845,021. Filed March 28, 1955. 3 claims. Assigned to Bemis Bro. Bag Co. [Cl. 101-228.]

Ringler, William A. Mechanism for forming and filling cigarette cartons. U. S. patent 2,844,929. Filed May 26, 1955. 6 claims. Assigned to The Diamond Match Co. (Cl. 53-230.]

Schilling, Hugh K. Stripping machine. U. S. patent 2,845,011. Filed May 4, 1955. 18 claims. Assigned to Horton Mfg. Co., Inc. [Cl. 93-36.] An apparatus is provided for stripping waste portions from diecut box blanks.

Smith, Hugh C. Apparatus for testing hot bleed and rub properties of printed heat sealable paper. U. S. patent 2,844,956. Filed April 2, 1956. 10 claims. Assigned to Kalamazoo Vegetable Parchment Co. [Cl. 73-15.4.]

Tamarin, Bernard J. Package with tear tab opening means. U. S. patent 2,845,213. Filed June 10, 1953. 4 claims. [Cl. 229-51.] An easy-opening cigarette pack is provided.

Then, Edward O. Coupling device for containers. U. S. patent 2,845,175. Filed April 25, 1955. 14 claims. Assigned to American Can Co. [Cl. 206-65.] Means are provided for joining two flat-top paperboard milk cartons in side-abutting relationship.

Vogt, Clarence W. Wrappers. U. S. patent 2,845,215. Filed Sept. 3, 1954. 5 claims. [Cl. 229-87.] A reinforced paperboard wrapper blank for use in packaging margarine, butter, etc., is provided.

Warner, Jesse J. Box folding and loading machine. U. S. patent 2,844,927. Filed May 20, 1952. 36 claims. [Cl. 53-186.] Candy boxes are set up and filled.

Ziehmer, George P., Jr. Coupling device for containers. U. S. patent 2,845,174. Filed April 22, 1955. 8 claims. Assigned to American Can Co. [Cl. 206-65.] This is similar to U. S. patent 2,845,175 (July 29, 1958).

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Ackermann, Franz. Water-soluble salts of derivatives of 4:4′-diaminostilbene-2:2′-disulfonic acid for enhancing the brightness of organic fibrous material. U. S. patent 2,846,397. Filed Oct. 2, 1950. 15 claims. Assigned to Ciba Ltd. [Cl. 252-89.]

Aichele, William J., and Davenport, Walter W. Confectionary product. U. S. patent 2,846,314. Filed Oct. 26, 1955. 15 claims. Assigned to General Foods Corp. [Cl. 99-139.] Various cellulose ethers are used.

Annable, Weldon G., O'Malley, Charles T., and Walsh, John W. High sealing-strength wax compositions. U. S. patent 2,846,375. Filed July 26, 1955. 7 claims. Assigned to Pure Oil Co. [Cl. 196-149.] Paraffin, microcrystalline, and petrolatum waxes are blended to form a high-sealing strength composition for coating paper and board.

Bowen, Robert E. Apparatus for screening pulp. U. S. patent 2,845,848. Filed Jan. 23, 1956. 8 claims. Assigned to North Carolina Pulp Co. [Cl. 92-34.] Various performance improvements in a cylindrical pulp screen are permitted by an arrangement of baffle plate and blades rotatably mounted in the screen.

Boynton, Donald E., and Dieckmann, Steffen F. Counter current contacting apparatus. U. S. patent 2,845,936. Filed May 9, 1955. 5 claims. Assigned to Hercules Powder Co. [Cl. 134-60.] The apparatus is suitable for contacting particulate solids with liquids, as in extracting pinewood chips, treating cellulose derivatives, etc.

Burden, Edward R. Self-locking folding box. U. S. patent 2,846,133. Filed Dec. 31, 1956. 1 claim. [Cl. 229-34.]

Carpenter, James R. Leakproof carton. U. S. patent 2,846,132. Filed Feb. 8, 1957. 6 claims. Assigned to Container Corp. of America. [Cl. 229-31.] A leakproof bellows-fold corner construction is provided in a paperboard frozen food carton.

Castiglione, Paul. Device for dispensing and applying an adhesive tape. U. S. patent 2,846,106. Filed Sept. 13, 1957. 3 claims. [Cl. 216-21.]

Clark, James d'A. Method and apparatus for depositing loose materials on support surfaces. U. S. patent 2,845,662. Filed June 13, 1956. 15 claims. Assigned to Changewood Corp. [Cl. 19-155.] Fibrous material is deposited on caul plates for pressing into board, with the excess being returned to the depositing means.

Didde, Carl W., and Glaser, Donald A. Sheet detector for paper gathering apparatus. U. S. patent 2,846,214. Filed Jan. 24, 1955. 5 claims. [Cl. 270-56.] A collating machine is provided with means to ensure that only one sheet of each type is included in each collated stack.

Fahrenbach, Wolfgang B. Carton carrier. U. S. patent 2,846,063. Filed May 31, 1955. 3 claims. Assigned to Edlo, Inc. [Cl. 206-65.] Two gable-top paperboard milk cartons are banded with paper and provided with a paperboard handle element secured between the cartons.

Foote, Allen M. Box cover. U. S. patent 2,846,130. Filed Oct. 18, 1955. 1 claim. [Cl. 229-7.] Household soap cartons are provided with a plastic element which fits over the top of the box and may be slidably moved to cover or uncover the dispensing opening.

Fox, Harold T. Combination envelope and easel for containing and/or framing pictures and the like. U. S. patent 2,845,733. Filed Dec. 12, 1956. 5 claims. Assigned to Tension Envelope Corp. of Kansas City. [Cl. 40-152.1.]

Gardner, Dwight R. Apparatus for feeding boxes. U. S. patent 2,846,116. Filed Feb. 2, 1955. 2 claims. Assigned to American Thread Co. [Cl. 221-67.] Small open-top boxes are removed from their nesting position in a supply stack and fed to a filling machine.

Goss, Worth C. Water soluble thermosetting resin and method for its manufacture. U. S. patent 2,846,431. Filed Oct. 1, 1951. 4 claims. Assigned to Permanente Cement Co. [Cl. 260-124.] The resin, derived from spent sulphite liquor, is of use in particle board binding, laminating, paper treating, etc.

Hahn, Willard E. Method and apparatus for producing bags. U. S. patent 2,845,849. Filed April 22, 1955. 8 claims. Assigned to St. Regis Paper Co. [Cl. 93-14.] A nongusseted satchel-bottom paper bag of superior strength is produced.

Herschler, Robert J., Jaffe, Rainer G., and Whipple, Francis O. Furfuryl alcohol polymer-protein-lignocellulose pulping liquor compositions and process of making the same. U. S. patent 2,846,409. Filed Jan. 23, 1956. 19 claims. Assigned to Crown Zellerbach Corp. [Cl. 260-8.] The product is of use as an adhesive, hardboard binder, and paper pulp additive.

Hiersteiner, Walter L. Envelope for two-way use. U. S. patent 2,846,135. Filed Sept. 29, 1954. 4 claims. Assigned to Tension Envelope Corp. [Cl. 229-73.]

Hopkins, Frank L., and Ayres, Richard H. Bag top closing and sealing machine. U. S. patent 2,845,760. Filed Nov. 5, 1956. 26 claims. Assigned to Bemis Bro. Bag Co. [Cl. 53-67.]

Howard, Edwin C. Rosin refining. U. S. patent 2,846,429. Filed Nov. 8, 1954. 3 claims. Assigned to Hercules Powder Co. [Cl. 260-107.] Low melting and neutral rosin constituents, useful in sizing, are removed from rosin by contacting the rosin in solution in a paraffinic hydrocarbon with a silica gel.

Huber, Erwin W. Self-destroying pressure sensitive label. U. S. patent 2,845,728. Filed April 3, 1957. 3 claims. Assigned to Topflight Corp. [Cl. 40-2.] A perforated line of weakening near the margins of the paper labels causes them to tear when an attempt is made to remove them from the surface to which they have been applied.

Kenney, John W., Jr. Sheet retaining device. U. S. patent 2,845,931. Filed Sept. 22, 1955. 1 claim. Assigned to Jerome J. Pluckebaum. [Cl. 129-1.] A simplified loose-leaf binder element is described.

La Guardia, Nicholas. Carrier or holder for bottles and the like. U. S. patent 2,846,115. Filed Dec. 24, 1954. 3 claims. [Cl. 220-113.] The carrier is for quart bottles.

Lawrence, Ray V., and Loeblich, Virginia M. Processing pine oleoresin. U. S. patent 2,846,430. Filed Nov. 30, 1956. 1 claim. Assigned to U. S. Secretary of Agriculture. [Cl. 260-109.] The resin acids are partially neutralized with aqueous alkali, and water and turpentine distilled off, to yield an oxidation-stabilized dry rosin for paper sizing.

Lowthian, Walter E. Method of packaging cylindrical containers. U. S. patent 2,845,758. Filed Jan. 19, 1956. 1 claim. [Cl. 53-14.] The containers are retained in apertures cut in a large paperboard sheet for use as a display panel or box insert.

Mestre, Luis. Sheet feeder for printing press. U. S. patent 2,846,220. Filed Oct. 12, 1953. 9 claims. Assigned to Lewfor Development Corp. [Cl. 271-31.] Improvements are made in suction sheet-separating and pile-elevating means.

Moubayed, Esber. Handle for paper bags and the like. U. S. patent 2,846,134. Filed Aug. 4, 1955. 1 claim. [Cl. 229-52.]

Newnham, Frank R. A. Ticket issuing machine. U. S. patent 2,845,886. Filed Oct. 18, 1955. 6 claims. Assigned to Medway Paper Sacks Ltd. [Cl. 112-11.] A bagging machine is provided with means to attach a label to the bag during the mouth-stitching operation.

Nichols, Gordon E. Calendar mount for calendar memo pads. U. S. patent 2,845,732. Filed March 9, 1955. 1 claim. Assigned to Winthrop-Atkins Co., Inc. [Cl. 40-152.1.]

Nickow, Louis, Nickow, Martin A., and Nickow, Hy. Label holder for binder. U. S. patent 2,846,238. Filed May 1, 1957. 3 claims. Assigned to General Loose Leaf Bindery Co., Inc. [Cl. 281-36.] A paperboard loose-leaf binder is provided with means for mounting a label.

Paige, Richard E. Holder for receptacles. U. S. patent 2,846,062. Filed Aug. 30, 1952. 3 claims. [Cl. 206-65.] Improved can-retaining means are provided in an open-end can carrier.

Ringler, William A. Collapsible bottle carriers. U. S. patent 2,846,114. Filed Feb. 27, 1953. 7 claims. Assigned to Diamond Match Co. [Cl. 220-113.]

Rowe, William. Tile shipping package. U. S. patent 2,846,064. Filed June 6, 1956. 6 claims. Assigned to Bonafide Mills, Inc. [Cl. 206-65.] Interior packing elements of corrugated board are provided to permit packaging of irregular-shaped tiles in a standard carton.

Savolainen, Unto U. Demonstration device. U. S. patent 2,846,059. Filed Sept. 6, 1957. 4 claims. Assigned to Metals & Controls Corp. [Cl. 206-29.] A bilayer metallic thermally responsive strip is incorporated in a conventional matchbook folder.

Smith, William A., Mattson, Vernon L., Meyer, Gene, and Baxter, Robert A. Concentration of potash ores containing sylvite. U. S. patent 2,846,068. Filed Jan. 14, 1952. 9 claims. Assigned to American Metal Climax, Inc. [Cl. 209-166.] Lignosulphonates are used.

Stempel, Laszlo M. Single sheet delivery device for web fed press. U. S. patent 2,846,046. Filed June 24, 1954. 6 claims. Assigned to John Waldron Corp. [Cl. 198-31.] A single sheet is withdrawn from the delivery stream for inspection purposes without disrupting the stream.

Strazdins, Edward. Nondusting modified rosin dry size. U. S. patent 2,846,328. Filed Aug. 4, 1955. 7 claims. Assigned to American Cyanamid Co. [Cl. 106-218.] Particles of maleic anhydride-modified rosin are coated with a refined hydrocarbon oil.

Struble, Glenn E. Tubular carton having automatically erectible diagonal partition. U. S. patent 2,846,131. Filed Aug. 10, 1955. 3 claims. Assigned to Diamond Gardner Corp. [Cl. 229-27.]

Supligeau, Charles L. H. Device for folding endless bands of paper. U. S. patent 2,846,215. Filed March 24, 1954. 2 claims. Assigned to Perine-Guyot & Cie-C. Supligeau. [Cl. 270-69.] The apparatus forms zigzag folds in a paper tape for accounting machines.

Svende, Ake K. E., and Westerlund, Karl O. Apparatus for a uniform distribution of a fibrous material on a conveyor belt. U. S. patent 2,845,661. Filed March 26, 1954. 2 claims. Assigned to Hoganas-Billesholms Aktiebolag. [Cl. 19-155.] Means for effecting air deposition of a fibrous web are described.

Tomarin, Harry A. Collar support. U. S. patent 2,846,127.

Filed July 10, 1956. 3 claims. Assigned to Loroco Industries Inc. [Cl. 223-83.]

Wilke, William J. Combined wire reel and shipping carton. U. S. patent 2,846,061. Filed April 19, 1955. 3 claims. [Cl. 206-59.]

Wilson, Joe B. Trimmer or paper cutter. U. S. patent 2,846,005. Filed Dec. 18, 1953. 1 claim. [Cl. 164-76.] Power means are provided to move the rotary cutting element in shearing engagement with the baseboard of the paper trimmer.

Wonsidler, Llewellyn. Packaging machine. U. S. patent 2,845,763. Filed June 26, 1956. 16 claims. [Cl. 53-157.] The machine interleaves meat slices and waxed paper to form stacks, then cartons the stacks.

Yount, Stanley G. Wrapping means for articles of sheet form. U. S. patent 2,846,060. Filed Nov. 15, 1954. 9 claims. [Cl. 206-58.] A paper wrapper having selected areas coated with adhesive is provided for wrapping plywood, hardboard, etc.

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Blumenthal, Lewis. Correspondence form. U. S. patent 2,847,235. Filed March 6, 1956. 3 claims. [Cl. 282-23.] An assembly of carbon sheets and paper folds into a remailable window envelope.

Brown, Donald E. Combination chipping and barker device. U. S. patent 2,847,045. Filed Jan. 3, 1956. 2 claims. [Cl. 144-162.]

Edwards, John H., and Tallis, Ernest E. Production of artificial filaments, threads, and the like. U. S. patent 2,847-272. Filed May 12, 1954. 5 claims. Assigned to Courtaulds, Ltd. [Cl. 18-54.] Thick-skinned noncrenulated viscose filaments are produced by adding to the viscose the sodium salt of mercapto benzthiazole.

Frankenstein, William P. Carton. U. S. patent 2,847,154. Filed June 29, 1951. 13 claims. [Cl. 229-31.] A hinged lid, openable to a display position, has both inner and outer faces formed to show the same side of the carton-forming material.

Gross, Frank C. Article orienting and conveying mechanisms. U. S. patent 2,847,108. Filed Sept. 25, 1957. 6 claims. Assigned to Package Machinery Co. [Cl. 198-33.] Cartons are filled, rotated 90°, transferred to another conveyor, and carried past flap-closing means.

Gross, Frank C. Method of an apparatus for making a carton. U. S. patent 2, 846, 930. Filed May 28, 1952. 4 claims. Assigned to Package Machinery Co. [Cl. 93-51.] Paperboard trays have their corners formed by a combination of gluing and tab-and-slit methods.

Guyer, Reynolds, and Dunning, Robert M. Dispenser box. U. S. patent 2,847,153. Filed Jan. 31, 1955. 8 claims. Assigned to Waldorf Paper Products Co. [Cl. 229-17.] A box for poultry feeds is provided with a tear tape-opening dispensing trough.

Haislet, John A. Tree poisoning axe. U. S. patent 2,846.817. Filed Sept. 6, 1955. 3 claims. Assigned to Riegel Paper Corp. [Cl. 47-57.5.]

Halley, Angus M. Web tension controlling device particularly for use in association with printing machines. U. S. patent 2,847,211. Filed April 16, 1956. 5 claims. [Cl. 271-2.3.]

Halley, Angus M. Web tension controlling means for use in association with printing machines. U. S. patent 2,847,210. Filed Dec. 6, 1954. 6 claims. [Cl. 271-2.3.]

Hickin, Robert J. Method of erecting cartons. U. S. patent 2,846,929. Filed June 13, 1955. 2 claims. Assigned to The Ohio Boxboard Co. [Cl. 93-36.] Improved corner-locking means are provided in cartons of the finished-edge or double-wall type.

Hofshagen, Olav. Arrangement of maps. U. S. patent 2,846,782. Filed Aug. 13, 1956. 2 claims. [Cl. 35-42.] An arrangement of maps on a stiff paperboard backing is described.

Kardon, Emanuel S., and Volksdorf, Hans. Method of making bags. U. S. patent 2,846,928. Filed Feb. 6, 1956. 2 claims. Assigned to American Bag & Paper Co. [Cl. 93-35.] An improved method of heat-sealing the bottom-forming flaps of paper bags is described.

Koch, Werner. Stacking device for printing machines. U. S. patent 2,847,215. Filed Dec. 9, 1954. 10 claims. Assigned to Faber & Schleicher A. G. [Cl. 271-88.]

Kruysman, Nicholas L. Fasteners. U. S. patent 2,847,155. Filed Dec. 12, 1956. 3 claims. [Cl. 229-77.] A paperboard file folder is provided with an elastic tying ribbon mounted so as to be replaceable.

La Padura, Margaret J. Dispensing container. U. S. patent 2,847,119. Filed Oct. 1, 1956. 1 claim. Assigned to Q-Tips, Inc. [Cl. 206-56.] An outer carton has a number of trays filled with cotton swabs; the tray are successively presented to an opening for drawer-like withdrawal.

Masci, Joseph N., and Ashton, William H. Method of making absorbent dental point. U. S. patent 2,846,927. Filed Oct. 25, 1954. Assigned to Johnson & Johnson. [Cl. 93-1.] A triangular blank of manila hemp paper is moistened, rolled to a point, and dried.

Meyer-Jagenberg, Gunther. Container made of paper, cardboard, or the like. U. S. patent 2,847,151. Filed Jan. 25, 1955. 1 claim. Assigned to Jagenberg-Werke A. G. [Cl. 229-7.] A foil liner element separates the contents of a tubular carton from the caplike carton end closure.

Miller, Ernest F., and Nichol, Wilbert G. Package for tin plate or the like. U. S. patent 2,847,120. Filed June 28, 1956. 1 claim. Assigned to U. S. Steel Corp. [Cl. 206-60.] The package comprises a banded paper- and paperboard-wrapped stack of tin plate sheets.

Mitchell, Reid L., Bampton, Robert F., and Wadman, William H. Process for producing hydroxyethoxycellulose. U. S. patent 2,847,411. Filed Feb 15, 1955. 2 claims. Assigned to Rayonier Inc. [Cl. 260-231.]

Olson, Edwin, Buckle type folding machine. U. S. patent 2,847,209. Filed Feb. 28, 1955. 1 claim. Assigned to Russel Ernest Baum, Inc. [Cl. 270-68.]

Rasch, Royal H., Fleming, Kenneth H., Leemhuis, Paul L., Sutton, Harvey. Semichemical pulp process. U. S. patent 2,847,304. Filed April 10, 1952. 9 claims. Assigned to Hammermill Paper Co. [Cl. 92-6.] The dirt and shive content of hardwood pulp is reduced.

Rodenhausen, Andreas. Gripper control for sheet printing machines. U. S. patent 2,846,947. Filed April 19, 1955. 2 claims. Assigned to Faber & Schleicher A.G. [Cl. 101-409.] The pressure of the grippers is varied during each printing cycle to offset the printing pressures.

Spriggs, George E. Package wrapping machines. U. S. patent 2,846,834. Filed June 8, 1954. 20 claims. Assigned to British Sugar Corp. Ltd. [Cl. 53-232.] A wrapper is sealed about packets of sugar.

Turner, Earl M. Sealing composition. U. S. patent 2,-847,315. Filed Sept. 26, 1955. 5 claims. Assigned to Mohawk Industries, Inc. [Cl. 106-123.] Tall oil is used in a caulking compound.

Van Antwerpen, Lloyd D. Shipping carton for wrap-around windshields and the like having foldable cushioning flaps. U. S. patent 2,847,152. Filed Nov. 19, 1956. 2 claims. [Cl. 229-14.]

Vuillemenot, Robert P. Boxes adapted for display of apparel. U. S. patent 2,847,117. Filed Aug. 19, 1957. 4 claims. Assigned to Maiden Form Brassiere Co. Inc. [Cl. 206-7.] Latching of the hinged body and lid elements is effected by an internal display member.

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Atkinson, James D., Jr. Protein compositions. U. S. patent 2,848,342. Filed March 3, 1955. 4 claims. Assigned to Buckeye Cellulose Corp. [Cl. 106-154.] A paper coating or adhesive composition capable of self-dispersion in water comprises a mixture of casein, urea, and a urease.

Bartell, Charles. Delamination treated pressure sensitive adhesive tape. U. S. patent 2,848,355. Filed May 26, 1955. 16 claims. Assigned to Permacel-Le Page's Inc. [Cl. 117-122.] The paper backing is impregnated with a synthetic rubber and a phenol-formaldehyde thermosetting resin and the paper is heat-cured.

Bartell, Charles, and Weschler, Joseph R. Improved normally tacky and pressure-sensitive adhesive tape. U. S. patent 2,848,105. Filed July 15, 1957. 23 claims. Assigned to Permacel-Le Page's Inc. [Cl. 206-59.] An impregnating composition is provided for treating paper to be used in backings for pressure-sensitive tape.

Beachler, Edward D. Papermaking machine drive and control means therefor. U. S. patent 2,847,912. Filed Aug. 4, 1951. 4 claims. Assigned to Beloit Iron Works. [Cl. 92-38.] A fourdrinier drive permits operation with wire and suction transfer roll in open or closed draw position without power transfer between the sections.

Beck, David C. Paper feeding machine. U. S. patent 2,848,219. Filed Jan. 3, 1957. 1 claim. Assigned to Liberty Folder Co. [Cl. 270-68.] A buckle-type paper sheet folding machine is designed so that the folding units, each with its own variable speed drive, are re-arrangeable.

Brook, Leonard, Wrapping machines. U. S. patent 2,-847,807. Filed Nov. 21, 1956. 6 claims. Assigned to Forgrove Machinery Co. Ltd. [Cl. 53-53.] Individually wrapped candies are discharged from a wrapping station past means which assure that each piece has been wrapped.

Buttner, Artur, Barthel, Karl, and Jung, Ludwig. Sheet-supplying device for printing and paper-working machines. U. S. patent 2,848,226. Filed Oct. 14, 1953. 10 claims. Assigned to Schnellpressenfabrik A.G. Heidelberg. [Cl. 271-12.]

Cage, James. Oleaginous food package. U. S. patent 2,848,336. Filed Jan. 26, 1955. 1 claim. Assigned to Reynolds Metals Co. [Cl. 99-179.] A paperboard wrapper for

butter sticks is designed to provide a block having smooth edges and sides to facilitate subsequent overwrapping.

Caswell, Benson E., and Theriault, Martin M. Article feeding apparatus. U. S. patent 2,848,138. Filed Feb. 19, 1952. 4 claims. Assigned to Keyes Fibre Co. [Cl. 221-209.] Molded pulp egg cartons are fed from a stack through a filling machine.

Cirrito, Anthony J. Stock inlet system for a papermaking machine. U. S. patent 2,847,913. Filed Feb. 7, 1956. 7 claims. Assigned to Rice Barton Corp. [Cl. 92-44.]

Costello, Edward J. Process for producing cellulose triesters. U. S. patent 2,848,343. Filed May 4, 1955. 12 claims. Assigned to American Viscose Corp. [Cl. 106-196.]

Cramer, Harold W. Envelope dispensing device. U. S. patent 2,848,137. Filed Dec. 8, 1954. 2 claims. [Cl. 221-36.]

Davey, Sidney M., and Anderson, John G. Means for packaging. U. S. patent 2,847,810. Filed Feb. 8, 1954. 18 claims. Anderson's interest assigned to Davey. [Cl. 53-198.] Stacks of paper currency are banded.

Davis, John S. Bag bottoming machine. U. S. patent 2,847,914. Filed March 9, 1956. 8 claims. Assigned to Equitable Paper Bag Co., Inc. [Cl. 93-14.] Improved means of opening the flattened bag tube for the bottoming operation are provided.

Davous, Leon. Packaging means. U. S. patent 2,848,132. Filed Jan. 25, 1951. 14 claims. [Cl. 217-23.] A cellular interior packing element is formed from superposed sheets of board laminated together along spaced narrow lines.

Diamond, Lester A. Simulated brick or the like wallpaper. U. S. patent 2,847,721. Filed Jan. 31, 1956. 1 claim. Assigned 50% to Bernard Sage and 50% to Joseph Sage. [Cl. 20-15.] Cork slabs are glued to heavy paper; a brick simulation results.

Frey, Raymond M., and Shiraga, Shiro F. Tall oil-phenolfuran resin compositions. U. S. patent 2,848,430. Filed Oct. 6, 1954. 12 claims. Assigned to McGraw-Edison Co. [Cl. 260-19.] The thermosetting resins produced are of use as substitutes for phenol-formaldehyde resins.

Gearhart, William M., and McAmis, Harry R. Cellulose organic acid ester plastics containing symmetrical diphenyl urea. U. S. patent 2,848,341. Filed April 23, 1954. 3 claims. Assigned to Eastman Kodak Co. [Cl. 106-106.] Ultraviolet light stabilization is achieved.

Geiger, Clarence H., Sr. Paper container and blank for constructing same. U. S. patent 2,848,152. Filed Oct. 31, 1956. 1 claim. [Cl. 229-17.] A hinged-lid closure element, including portions of several of the carton panels, is provided in a carton for cigarettes, candy, etc.

Geiger, Clarence H., Sr. Paper container and blank for constructing same. U. S. patent 2,848,153. Filed Oct. 31, 1956. 5 claims. [Cl. 229-17.] This is similar to U. S. patent 2,848,152 (Aug. 19, 1958).

Gyllenberg, John L. Slab barker having scraper. U. S. patent 2,848,022. Filed Nov. 9, 1956. 2 claims. Assigned to Anthony Brandenthaler. [Cl. 144-208.] Slabs are completely debarked without permitting contact of the conveyor spikes with the barking elements.

Hanson, Roger H. Carboard carton and integral handle assembly. U. S. patent 2,848,154. Filed Sept. 24, 1954. 1 claim. [Cl. 229-52.] In a can carrier, the handle element is an extension of a side panel and may be folded flat during shipment.

Hawkins, Wallace G. Machine for forming thermoplastic impregnated fibrous blanks. U. S. patent 2,847,706. Filed March 18, 1955. 2 claims. Assigned to C. & J. Clark Ltd. [Cl. 18-19.] Resin-impregnated leatherboard preforms are heated before being molded into shoe elements and the like.

Jensen, Thormod. Registration device for wrapping machines. U. S. patent 2,848,224. Filed Sept. 20, 1952. 11 claims. Assigned to American Machine & Foundry Co. [Cl. 271-2.6.] The printed area of a bread wrapper is properly registered on the bread loaf.

Kimbro, John J. Sheet feeding assembly. U. S. patent 2,848,228. Filed Dec. 30, 1954. 2 claims. Assigned to Radio Corp. of America. [Cl. 271-26.] A suction-type label feeder is provided with means assuring the feeding of only one label at a time.

Meyerhoefer, Carl E. Filter bag. U. S. patent 2,848,062. Filed March 8, 1957. 1 claim. Assigned to Lewyt Corp. [Cl. 183-51.] A paper vacuum cleaner bag has an area within the bag covered with a strip of kraft paper to prevent penetration of airborne particles entering the bag.

Meyerhoefer, Carl E. Filter bag. U. S. patent 2,848,063. Filed March 8, 1957. 1 claim. Assigned to Lewyt Corp. [Cl. 183-51.] A paper vacuum cleaner bag has an area impregnated with resin to prevent penetration of airborne particles entering the bag.

Murphy, Joseph P., and Weimer, Kenneth A. Insulation ventilator tube. U. S. patent 2,848,016. Filed Jan. 17, 1955. 3 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 138-78.] Of use in building construction, the assembly comprises two telescoping paperboard tubes.

O'Neil, John G. Sealed container. U. S. patent 2,848,151. Filed Oct. 6, 1954. 3 claims. Assigned to Safe-Pack Container Co. [Cl. 229-4.5.] A method of seaming a container comprising a cylindrical tube formed of a foilboard laminate is described.

Peterson, William R. Bag closing apparatus. U. S. patent 2,847,955. Filed Nov. 21, 1955. 2 claims. Assigned to St. Regis Paper Co. [Cl. 112-11.] A closure tape is folded over a bag mouth and the elements properly positioned during stitching of the closure.

Price, Lloyd R., and Ferguson, Robert T., Jr. Tag-making machine and method. U. S. patent 2,848,225. Filed Feb. 10, 1956. 21 claims. Assigned to Robinson Tag & Label Co. [Cl. 271-2.6.] The web of paper tag-making material may be minutely registered as the web is running.

Rapp, Raymond I. Method of producing envelopes. U. S. patent 2,847,915. Filed Dec. 23, 1954. 1 claim. Assigned 50% to William R. Peterson. [Cl. 93-61.]

Ringler, William A. Multicell bottle carriers. U. S. patent 2,848,136. Filed Oct. 11, 1952. 3 claims. Assigned to Diamond Match Co. [Cl. 220-113.]

Romine, James W. Tree wrapping machine. U. S. patent 2,847,808. Filed Sept. 6, 1956. 7 claims. Assigned to Greening Nursery Co. [Cl. 53-124.] The apparatus packs the roots of a tree into a paper bag.

Ross, Frank, and Mellick, Charles. Vapor-phase corrosion inhibition. U. S. patent 2,848,298. Filed Nov. 23, 1954. 26 claims. Assigned to Dearborn Chemical Co. [Cl. 21-2.5.] The inhibitor used in making VPI paper comprises a mixture of a nitrous acid salt and a metallic salt of a 6–10 carbon alkanoic acid.

Roy, Henri G. Artificial lumber products and their manufacture. U. S. patent 2,847,733. Filed Sept. 2, 1955. 16 claims. [Cl. 20-91.] Wood-particle board has reinforcing metal filaments embedded therein.

Schor, Abraham, and Rudnick, Robert J. Dispensing protective packages for a plurality of rolls of web material. U. S. patent 2,848,104. Filed Aug. 21, 1956. 5 claims. Schor's interest assigned to Rudnick. [Cl. 206-58.] A dispensing carton holds several heavy rolls of paper so that they may be drawn out in superposed relation for use.

Stephens, Frederick N., and Perkins, Carl C., Jr. Linear feed mat winding machine. U. S. patent 2,848,175. Filed May 17, 1954. 23 claims. Assigned to Gustin-Bacon Mfg. Co. [Cl. 242-55.1.] Each mat in a series is automatically and successively wrapped about one of a series of mandrels to form tubes for insulating and the like.

Talmey, Paul. Methods of making printed electric circuits. U. S. patent 2,848,359. Filed June 20, 1955. 13 claims. Assigned to General American Transportation Corp. [Cl. 117-212.] The base used is laminated resin-impregnated paper.

Truitt, William G. Composite roofing strip. U. S. patent 2,847,948. Filed May 6. 1955. 2 claims. [Cl. 108-6.] Aluminum foil is laminated to asphalt paper, with two opposite edges of the foil overlapped about the paper edges.

Ward, Richard E. Combination carrier and container. U. S. patent 2,848,149. Filed March 20, 1957. 3 claims. Assigned to Weyerhaeuser Timber Co. [Cl. 224-46.] A U-shaped handled carrier of hardboard is provided for fireplace logs, magazines, books, etc.

Welch, Arthur R. Apparatus for depositing overlay material on plywood panels. U. S. patent 2,847,701. Filed May 9, 1952. 10 claims. [Cl. 18-4.] Wood particles and binder are deposited in a uniform layer suitable for pressing into board.

White, Percy, and Bowmer, Henry L. Method of packaging ice cream. U. S. patent 2,848,337. Filed Feb. 8, 1955. 1 claim. Assigned to J. Lyons & Co. Ltd. [Cl. 99-180.] Ice cream is extruded into a paperboard channel-forming blank which is then wrapped about the ice cream.

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Beaulieu, Delton C. Revolving layboy piler. U. S. patent 2,849,236. Filed Sept. 14, 1954. 3 claims. Assigned to Kimberly-Clark Corp. [Cl. 271-88.] Filed Sept. 14, 1954. 3 claims. Assigned to Kimberly-Clark Corp. [Cl. 271-88.]

Brock, Richard A. Lid forming machine. U. S. patent 2,848,856. Filed June 3, 1957. 5 claims. [Cl. 53-287.] The filled box body is used as a mandrel about which a telescoping box cover element is formed.

Brucker, Francis X. Wrapped ham. U. S. patent 2,849,-322. Filed June 27, 1955. 21 claims. [Cl. 99-174.] A multi-ply wrapping sheet includes plies of greaseproof paper, absorbent paper, and waxed glassine.

Clark, James d'A. Machine for producing fibrous wafers. U. S. patent 2,849,038. Filed June 16, 1954. 10 claims. Assigned to Changwood Corp. [Cl. 144-172.] Small slabs of

wood or scrap wood materials are reduced to wafers for use in producing structural boards.

Evans, John L. Liquid coating composition comprising a methyl methacrylate polymer and cellulose acetate butyrate. U. S. patent 2,849,409. Filed Feb. 7, 1956. 5 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 260-17.]

Fielding, Francis W. Article carrier. U. S. patent 2,849,111. Filed Oct. 17, 1955. 4 claims. Assigned to Lensfield Brothers, Inc. [Cl. 206-65.] A six-pack can carrier is described.

Forrer, Homer W. Paperboard carrier having embossed end edge portions. U. S. patent 2,849,112. Filed Feb. 20, 1957. 6 claims. Assigned to Mead-Atlanta Paper Co. [Cl. 206-65.] A six-pack can carrier is described.

Franghia, Sava B. Machines for producing containers. U. S. patent 2,848,927. Filed Feb. 17, 1955. 2 claims. [Cl. 93-60.] In a cup-forming machine, improved means are provided for forming a flanged cup lip.

Gadler, Gustav A. B. Machine for winding paper material in rolls. U. S. patent 2,849,191. Filed Feb. 9, 1955. 13 claims. Assigned to Arenco AB. [Cl. 242-56.] A machine for the continuous coreless winding of rolls of paper is described.

Gartrell, Charles W., and Gartrell, Kathryn W. Cigarette package. U. S. patent 2,849.154. Filed Jan. 5, 1956. 2 claims. [Cl. 221-260.] A cigarette package is provided with string-actuated pull-tab means for with-drawing the cigarettes.

Goss, Worth C. Process of treatment and products from waste sulfite liquors. U. S. patent 2,849,314. Filed March 2, 1953. 10 claims. Assigned to Permanente Cement Co. [Cl. 92-3.] By reaction with ammonia, thermosetting resins of use in papermaking are produced.

Gschwind, Edouard E., and Greene, Ralph N. Carton erecting machine. U. S. patent 2,848,926. Filed April 17, 1956. 15 claims. Assigned to Owens-Illinois Glass Co. [Cl. 93-51.]

Guarino, Michael A. Pencil point cleaner. U. S. patent 2,848,729. Filed March 9, 1955. 3 claims. [Cl. 15-223.] Several folded and stacked sheets of soft tissue paper are stapled between top and bottom sheets of paperboard.

Haglund, Gustaf. Digestion of wood. U. S. patent 2,849,315. Filed April 30, 1954. 2 claims. [Cl. 92-11.] A two-stage sulphite pulping process is described.

Halahan, John, Aronson, Theodore F., and Lyon, Floyd A. Sheet feeder. U. S. patent 2,849,232. Filed Jan. 7, 1955. 4 claims. [Cl. 271-29.] Combined suction and air-blast means are used to effect sheet separation from the supply pile.

Hart, Robert T. Process of forming an insolubilized protein film on a base. U. S. patent 2,849,334. Filed Nov. 4, 1954. 2 claims. Assigned to S. D. Warren Co. [Cl. 117-64.] A metallic complex included in the paper coating composition effects insolubilization of the protein component during drying.

Heise, George W., and Cahoon, Nelson C. Multi-ply washer for the prevention of electrolyte creepage. U. S. patent 2,849,521. Filed Sept. 21, 1954. 5 claims. Assigned to Union Carbide Corp. [Cl. 136-133.] The washer is formed of several layers of absorbent paper laminated with films of methylcellulose or the like.

Hoffman, Henry A., Jr., and Wilkinson, William K. Cellulose derivatives. U. S. patent 2,849,330. Filed June 1, 1955. 28 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 106-169.] A method of improving the affinity of cellulose derivatives for basic dyes is described.

Jackson, Donald R. P. Apparatus for feeding sheets. U. S. patent 2,849,233. Filed June 7, 1955. 4 claims. Assigned to Molins Machine Co. [Cl. 271-43.] Apparatus is provided to feed paperboard sheets to a machine for forming container blanks.

Jonsson, Einar J. J. Bale presses for paper, rags, straw, peat, and the like. U. S. patent 2,848,940. Filed July 26, 1956. 1 claim. [Cl. 100-255.]

Krueger, Theodore H. Feed control for strip dispenser. U. S. patent 2,849,067. Filed April 1, 1955. 7 claims. Assinged to Better Packages Inc. [Cl. 164-49.] A machine for serving gummed carton-sealing tape is provided with improved means controlling the length of tape served.

Krueger, Theodore H., and Sharpe, Everett E. Tacky tape dispenser with tape straightening means. U. S. patent 2,849,065. Filed May 10, 1954. 5 claims. Assigned to Better Packages, Inc. [Cl. 164-39.]

Kruysman, Nicholas L. Fastener. U. S. patent 2,849,172. Filed June 9, 1955. 1 claim. [Cl. 229-77.] An expandable paperboard file folder envelope is provided with improved means for attaching an elastic closure element.

Lamm, Raymond R. Adhesive composition including limed rosin and acrylic plasticizer. U. S. patent 2,849,410. Filed Sept. 24, 1954. 2 claims. Assigned to Patent and Licensing Corp. [Cl. 260-27.] The composition is for use in installing acoustical board, gypsum board, and like materials.

Laufer, Frederic. Machines for operating on sheets, such for example as a strip-cutting press or a press for corrugating cardboard sheets. U. S. patent 2,849,235. Filed March 30, 1955. 3 claims. Assigned to J. Bobst & Son S. A. [Cl. 271-50.]

Lauring, Edgar A. Method of producing flame resistant fiberboard. U. S. patent 2,849,316. Filed Sept. 5, 1956. 7 claims. Assigned to Minnesota and Ontario Paper Co. [Cl. 92-21.] Anhydrous borax is added to the pulp and the pulp is sheeted within 3 min. of the time of the addition.

Lincoln, Dwight C. Stabilized cellulose ether composition. U. S. patent 2,849,325. Filed June 28, 1952. 8 claims. Assigned to Hercules Powder Co. [Cl. 106-189.] A polycyclic phenol is employed as a weathering-stabilization agent in ethylcellulose compositions.

Lytton, Marion R. Producing all skin viscose rayon. U. S. patent 2,849,274. Filed Nov. 3, 1954. 5 claims. Assigned to American Viscose Corp. [Cl. 18-54.] This is similar to U. S. patent 2,847,272 (Aug. 12, 1958); the additive being an alkali-soluble alkylene oxide adduct of a *p*-aliphatic aniline.

O'Brien, Charles S., Jr. Bag with tie member for closing and carrying it. U. S. patent 2,849,171. Filed Aug. 31, 1953. 3 claims. Assigned to Bemis Bro. Bag Co. [Cl. 229-63.]

Palmer, Leon B. Backing for smooth surface coverings and process therefor. U. S. patent 2,849,335. Filed Sept. 17, 1956. 33 claims. Assigned to Congoleum-Nairn Inc. [Cl. 117-68.] The fibrous felt backing is impregnated on one side with asphalt and on the other side with asphalt an an organopolysiloxane.

Pascale, Martin M., and Rickus, George M. Hat ring. U. S. patent 2,849,108. Filed Jan. 20, 1956. 4 claims. Assigned to Hat Corp. of America. [Cl. 206-9.] A paperboard interior packing element is provided for use in hat boxes.

Rommel, Max. Razor blade package. U. S. patent 2,849,109. Filed Aug. 19, 1953. 2 claims. [Cl. 206-46.] A razor blade is adhesively sealed between two strips of paper having an easy-opening tear line.

Ross, Jacob F., and Smith, Albert. Powder box. U. S. patent 2,849,170. Filed Jan. 31, 1957. 6 claims. Assigned to Coty, Inc. [Cl. 229-43.] In a telescoping cover box, anti-powder-sifting means are provided.

Rowlands, Tom, Osborn, Howard, and Hubbard, Henry J. Sheet feeding mechanism. U. S. patent 2,849,234. Filed June 9, 1955. 6 claims. Assigned to Molins Machine Co. [Cl. 271-44.] Improved box-blank feeding means are provided.

Ryan, John J., and Weidener, Richard A. Cold-water-soluble dextrine adhesive and process of making it. U. S. patent 2,849,327. Filed Feb. 16, 1954. 10 claims. Assigned to National Starch Products Inc. [Cl. 106-208.]

Schoenberger, John J., and Turula, Gabriel T. Paper coating composition and process of making it. U. S. patent 2,849,326. Filed June 21, 1955. 3 claims. Assigned to Corn Products Refining Co. [Cl. 106-205.] A ready-to-use paper coating composition comprises water, a starch-derived polymer, and a pigment.

Shick, Philip E. Pulp manufacture. U. S. patent 2,849,292. Filed April 9, 1956. 8 claims. Assigned to Mead Corp. [Cl. 23-262.] Apparatus is provided for effecting recovery of heat and chemicals from spent sulphite liquor.

Smith, Oreal R., and Powell, John E., Jr. Wrinkle coating composition, article, and method. U. S. patent 2,849,332. Filed Aug. 24, 1955. 29 claims. Assigned to B. F. Goodrich Co. [Cl. 117-41.] The composition, for application to cellulosic and other surfaces, includes polyvinyl chloride, tetraethylene glycol dimethacrylate, butyl acrylate, and a plasticizer.

Steinmann, Henry W. Process for the preparation of organic acid esters of cellulose. U. S. patent 2,849,444. Filed June 22, 1955. 13 claims. Assigned to Celanese Corp. of America. [Cl. 260-230.]

Steinmann, Henry W. Production of organic acid esters of cellulose. U. S. patent 2,849,441. Filed July 16, 1954. 23 claims. Assigned to Celanese Corp. of America. [Cl. 260-230.]

Steinmann, Henry W. Production of organic acid esters of cellulose by the homogeneous process. U. S. patent 2,849,440. Filed Aug. 16, 1955. 15 claims. Assigned to Celanese Corp. of America. [Cl. 260-227.]

Steinmann, Henry W. Production of organic acid esters of cellulose in homogeneous solution with subsequent multiple phase extraction. U. S. patent 2,849,442. Filed Nov. 23, 1954. 22 claims. Assigned to Celanese Corp. of America. [Cl. 260-230.]

Steinmann, Henry W. Treatment of solutions of organic acid esters of cellulose. U. S. patent 2,849,439. Filed June 28, 1955. 20 claims. Assigned to Celanese Corp. of America. [Cl. 260-227.]

Steinmann, Henry W., and Dunay, Michael. Production of organic acid esters of cellulose. U. S. patent 2,849,443. Filed March 3, 1955. 9 claims. Assigned to Celanese Corp. of America. [Cl. 260-230.]

Strine, Eli R. Bag closing mechanism. U. S. patent 2,848,961. Filed Nov. 21, 1955. 6 claims. [Cl. 112-11.] The

device holds the mouth portion of a filled paper bag in proper position for sealing.

Swinehart, Richard W., and Greminger, George K. Cold-sealing water-soluble thermoplastic cellulose ether composition. U. S. patent 2,849,328. Filed Nov. 25, 1953. 6 claims. Assigned to The Dow Chemical Co. [Cl. 106-176.]

Tennant, James L., Jr. Plant container with fibrous walls holding a root growth inhibitor. U. S. patent 2,848,842. Filed June 28, 1955. 10 claims. Assigned to Bird & Son, Inc. [Cl. 47-34.] The paper or molded pulp container is impregnated with asphalt and a chemical inhibitor.

Tuttle, John N. Dispenser carton. U. S. patent 2,849,152. Filed Nov. 15, 1954. 6 claims. Assigned to Rhinelander Paper Co. [Cl. 221-48.] A carton for packaging and dispensing interfolded paper sheets is constructed so that the pack of sheets is urged toward the dispensing opening.

Tuttle, John N. Dispensing device. U. S. patent 2,849,153. Filed June 29, 1956. 4 claims. Assigned to Rhinelander Paper Co. [Cl. 221-57.] This is similar to U. S. patent 2,-849,152 (Aug. 26, 1958).

Wallin, Sven W., and Allander, Claes. Method and apparatus for supporting and conveying web-like material. U. S. patent 2,848,820. Filed Oct., 5, 1953. 9 claims. Assigned to AB. Svenska Flaktfabriken. [Cl. 34-23.] In an air cushion conveying system for a web of cellulose pulp, means are provided to prevent fluttering of the web.

Watts, Aaron P. Bag valve opener. U. S. patent 2,848,857. Filed Feb. 9, 1955. 2 claims. Assigned to Diamond Alkali Co. [Cl. 53-384.] The device opens the valves of valve bags preparatory to receiving the nozzle of a filling machine.

Weigham, William R. Process for the production of alkali cellulose. U. S. patent 2,849,445. Filed Nov. 12, 1953. 2 claims. Assigned to Courtaulds Ltd. [Cl. 260-233.]

Weiss, Adolph. Container coupler. U. S. patent 2,849,110. Filed Dec. 2, 1952. 5 claims. Assigned to American Can Co. [Cl. 206-65.] Two flattop paperboard milk cartons are banded together in a handled unit.

Werberig, Cornelius. Printed circuitry laminates and production thereof. U. S. patent 2,849,298. Filed May 3, 1955. 3 claims. Assigned to St. Regis Paper Co. [Cl. 41-43.] The method described involves the use of resin-impregnated paper.

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Archer, George W. Log choker guide. U. S. patent 2,-850,315. Filed Jan. 7, 1955. 4 claims. [Cl. 294-55.]

Biel, Hans, and Pfäffle, Ernst. Method for trimming, cutting, and cornering folded paper articles. U. S. patent 2,850,090. Filed Sept. 25, 1956. 3 claims. Assigned to Hans Sickinger. [Cl. 164-17.]

Blundin, Warren S. Feeder for fibrous materials. U. S. patent 2,850,183. Filed Jan. 2, 1953. 3 claims. Assigned to Badcock & Wilcox Co. [Cl. 214-18.] Bagasse is fed to a furnace.

Bottoms, Robert R. Method of increasing the immunity of cellulose to decay and treated article. U. S. patent 2,850,405. Filed Jan. 17, 1957. 6 claims. Assigned to National Cylinder Gas Co. [Cl. 117-65.] Cellulosic materials are impregnated with aqueous copper acrylate or furoate, then heated.

Brooks, Maxwell J., and Swaine, James W. Fluid burning of finely divided sulfide ore concentrates. U. S. patent 2,850,-371. Filed April 11, 1956. 6 claims. Assigned to Allied Chemical Corp. [Cl. 75-9.]

D'Angelo, Joseph, and Di Nunzio, Joseph. Perforating apparatus. U. S. patent 2,850,093. Filed Dec. 6, 1955. 9 claims. Assigned to Roto Bag Machine Corp. [Cl. 164-94.] A tube or web of bag or package forming material is perforated for ventilation while the web is moving through the container-forming machine.

Dereich, John E. Silicate glass adhesive composition. U. S. patent 2,850,397. Filed May 13, 1953. 9 claims. Assigned to Diamond Alkali Co. [Cl. 106-83.] For use in making corrugated board and the like, the adhesive, containing a minor amount of a pine wood resin, does not adhere to the heated surfaces of converting machines.

Dunlap, Arthur H. Joint tape. U. S. patent 2,850,404. Filed Nov. 21, 1955. 8 claims. [Cl. 117-44.] Adhesive-coated wallboard joint tape is provided with perforated marginal areas.

Erskine, Archibald M., Gorin, Manuel H., Rosenstein, Ludwig, and Chesbro, Ruth M. Organic ammonium salts of lignin acids. U. S. patent 2,850,492. Filed March 2, 1954. 7 claims. Erskine and Chesbro's interests assigned to Gorin and Rosenstein. [Cl. 260-124.] The products are antimicrobial agents of use in papermaking; the lignins are derived from spent liquors or redwood.

Freeman, Horace, and Boadway, John D. Method and apparatus for treating pulp suspensions and other fluids for removal of undesired particles and gases. U. S. patent 2,849,-930. Filed Dec. 6, 1952. 5 claims. Assigned to Nichols Engineering and Research Corp. [Cl. 92-28.] A vortex-type separator is described.

Giggey, James W. Remoistenable adhesive comprising polyvinyl acetate, polyvinyl alcohol, and a plasticizer and method of preparation. U. S. patent 2,850,468. Filed April 8, 1955. 4 claims. Assigned to E. I. de Pont de Nemours and Co. [Cl. 260-17.4.]

Guggenheim, Max M. Guides for box-wrapping machines. U. S. patent 2,849,849. Filed April 29, 1955. 1 claim. Assigned to National Equipment Corp. [Cl. 53-387.] Adjustable guides permit the wrapping of different sized boxes.

Heimlicher, Paul, and Vetter, Ludwig. Sheet collectors for collecting paper sheets into piles. U. S. patent 2,850,281. Filed Oct. 14, 1953. 4 claims. Assigned to Maschinenfabrik Winkler, Fallert & Co. A.G. [Cl. 271-71.] A modified collector star permits more efficient transition from one pile to the next.

Hultin, Oscar H. Package. U. S. patent 2,850,222. Filed June 9, 1955. 6 claims. Assigned to Pneumatic Scale Corp., Ltd. [Cl. 229-17.] Opening the closure flap of a lined carton for pourable solids also ruptures the liner, the liner and outer carton then describing a dispensing opening for the solids.

Johnson, Samuel L. Worm box. U. S. patent 2,849,828. Filed April 2, 1956. 8 claims. [Cl. 43-55.] A metal-framed, Celotex-walled, Masonite-covered box for fisherman's bait is described.

Kalbermatten, Bruno de. Machines for operating on sheets, such for example as a strip-cutting press or a press for corrugating cardboard sheets. U. S. patent 2,850,280. Filed March 30, 1955. 7 claims. Assigned to J. Bobst & Son S. A. [Cl. 271-60.] The sheets are registered without reversing their direction of travel.

Klein, Walter A., Mason, Albert J., and Holzschu, John. Dispensing box for sheet wrapping material. U. S. patent 2,850,157. Filed April 10, 1957. 6 claims. Assigned to Dow Chemical Co. [Cl. 206-58.] A paperboard dispensing carton for giant-size rolls of wrapping paper and he like is provided.

McGihon, Leonard. Carton. U. S. patent 2,850,159. Filed Jan. 8, 1954. 1 claim. Assigned to King Sales & Engineering Co. [Cl. 206-65.] A six-pack can-carrier is described.

McGihon, Leonard. Carton closing machine. U. S. patent 2,849,846. Filed Nov. 16, 1953. 7 claims. Assigned to King Sales & Engineering Co. [Cl. 53-374.]

Marcuse, Moses M., and Morin, Louis H. Dispenser for fanfold towels. U. S. patent 2,850,345. Filed Nov. 23, 1954. 15 claims. Assigned to West Chemical Products, Inc. [Cl. 312-39.] A wall-mounted device dispenses stacks of paper towels having guide notches cut along one edge of the stack with provision made for adhesive interconnection of successive stacks.

Marogg, Richard. Method and apparatus for making filter rods. U. S. patent 2,849,932. Filed Jan. 31, 1955. 18 claims. Assigned to Peter J. Schweitzer, Inc. [Cl. 93-1.] A cigarette filter comprises a paper-wrapped rodlike bundle of lacerated gathered stretched paper.

Matheny, Hollis B. Card holder. U. S. patent 2,850,016. Filed Sept. 21, 1955. 1 claim. Assigned to Sperry Rand Corp. [Cl. 129-16.7.] A folder is provided for holding an index card or the like of the type used in a business card record system.

Meinhardt, John W., and Tabor, Dewey W. Tray box for small bakery products. U. S. patent 2,850,224. Filed May 25, 1955. 1 claim. Assigned to Crown Zellerbach Corp. [Cl. 229-27.]

Nordquist, Ronald E. J. Carrying device for containers. U. S. patent 2,850,319. Filed Dec. 15, 1955. 8 claims. Assigned to American Can Co. [Cl. 294-87.2.] A handle element is provided for flat-top paperboard milk cartons.

Ortis, Charles, and Spertus, Maurice. Picture album. U. S. patent 2,850,294. Filed March 6, 1953. 3 claims. Assigned to R. and E. Molding Corp. [Cl. 281-31.] The loose-leaf construction conceals binder elements, prevents page tearing, and permits page removal without dismantling the binder.

Painter, Claude D. Cellular bottle carrier. U. S. patent 2,850,205. Filed Oct. 6, 1953. 2 claims. [Cl. 220-105.]

Pasjack, Steve. Collapsible carry carton. U. S. patent 2,850,206. Filed Feb. 27, 1956. 9 claims. [Cl. 220-105.] A totally enclosed can carrier has handle-forming elements erectable from the plane of the top panel.

Plumley, Glenn V., Stevens, William B., and Dudish, Alice M. Faced honeycomb building material. U. S. patent 2,-849,758. Filed April 18, 1955. 1 claim. [Cl. 20-15.] Paper honeycomb is faced on one side with resin-impregnated fiberglass and on the other side with a decorative sheet.

Shamberg, Morris F., and Blythe, James E. Packaging insert for packing box. U. S. patent 2,850,155. Filed Feb. 19, 1957. 14 claims. Assigned to U. S. Secretary of the Army. [Cl. 206-46.] A paperboard blank sets up to form a supporting structure for maintaining two military caps in proper position in an outer carton.

Siebel, George E., Lister, William G., and Giordan, Michael. Package. U. S. patent 2,850,160. Filed Nov. 23, 1956. 5

claims. Assigned to Central Products Co. [Cl. 206-65.] A paper sheet is folded and locked about a transparent bag.

Stoothoff, Stanley T., and Williams, Leo C. Sheet separator. U. S. patent 2,850,279. Filled March 29, 1954. 25 claims. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 271-26.] The conventional cylinder-and-piston arrangement is eliminated in a suction sheet separator for use on printing machines and the like.

Strauss, Herman H. Carrier for articles. U. S. patent 2,850,223. Filed Jan. 10, 1955. 1 claim. Assigned to Crown Zellerbach Corp. [Cl. 229-27.] A heavy-duty re-usable carrier comprises a paperboard tray having a single centrally located vertical partitioning and handle member.

Toensmeier, Patrick A. Carrier cartons. U. S. patent 2,850,207. Filed May 4, 1956. 1 claim. Assigned to New Haven Board & Carton Co. [Cl. 220-115.] A 4-part partitioned bottle carrier with extensible handle element is described.

Van Dam, John F., Jr. Label applying machine. U. S. patent 2,850,195. Filed Feb. 4, 1955. 13 claims. Assigned to Xabel Engineering Co. [Cl. 216-52.]

Vay, Spencer B. Portable commode. U. S. patent 2,849,726. Filed June 28, 1955. 9 claims. [Cl. 4-134.] Corrugated board is used.

von Hofe, George W. Method and apparatus for attaching articles composed of thermoactivatable material. U. S. patent 2,849,933. Filed Feb. 10, 1955. 21 claims. Assigned to New Jersey Machine Corp. [Cl. 93-56.] Means are provided for heat-sealing thermoactivatable stay tape to box corners.

Witt, Everett E., and Holt, Frederick W., Jr. Dextran bone glue adhesives. U. S. patent 2,850,398. Filed June 18, 1956. 20 claims. Assigned to Commonwealth Engineering Co. [Cl. 106-129.]

Woodward, Tracey. Protective holder for disk recordings. U. S. patent 2,850,158. Filed July 29, 1957. 6 claims. [Cl. 206-62.] A laminated paperboard structure is described.

Zarges, Walther. Reversible address support for shipping containers. U. S. patent 2,849,812. Filed Dec. 13, 1956. 12 claims. [Cl. 40-5.]

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Arneson, Edwin L. Setup machine. U. S. patent 2,850,954. Filed Oct. 18, 1956. 15 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 93-51.] The machine folds, sets up, and glues precut and prescored paperboard blanks to form traylike cartons.

Barker, Charles, and Gentry, Hermond G. Method and means for initially flexing foldable paperboard carton handle portions and the like. U. S. patent 2,850,953. Filed March 25, 1957. 10 claims. Assigned to Mead-Atlanta Paper Co. [Cl. 93-36.] The handle elements are prebent in a machine for making six-pack can cartons.

Battenberg, Ernst, and Haas, Heinz. Process for the preparation of semicellulose. U. S. patent 2,851,355. Filed Nov. 15, 1951. 3 claims. Assigned to Zellstofffabrik Waldhof. [Cl. 92-11.] A semichemical pulping process is described.

Bergstein, Frank D. Shallow wall automatic box. U. S. patent 2,851,209. Filed Dec. 14, 1956. 2 claims. Assigned to Bergstein Packaging Trust. [Cl. 229-32.]

Bergstein, Robert M. Boxes having reversible handles. U. S. patent 2,851,211. Filed March 22, 1954. 3 claims. Assigned to Bergstein Packaging Trust. [Cl. 229-52.] A separate handle member is applied before folding and gluing, the handle lying flat against the interior side and bottom surfaces of the open-top box until reversed for use.

Berlinghof, William L., Jr. Conductive ink and article coated there-with. U. S. patent 2,851,380. Filed Feb. 9, 1953. 4 claims. Assigned to Woodmont Products, Inc. [Cl. 117-212.] The ink provided is suitable for application to resin-impregnated paper laminates in the production of printed circuits.

Broyles, Horace N., Evans, George W., Pavoni, Paul, and Kindel, William H. Packing apparatus. U. S. patent 2,850,857. Filed Oct. 18, 1954. 16 claims. Assigned to United Mattress Machinery Co. [Cl. 53-124.] Mattresses are packed into paper bags.

Carman, Charles M., Jr. Fastener. U. S. patent 2,851,038. Filed July 21, 1953. 5 claims. [Cl. 129-41.] A prong-type fastener of metal or plastic construction is employed to bind together the sheets in a stack of paper.

Daly, John L., Hall, George B., and Taylor, Harry W. Apparatus for applying covers to cartons. U. S. patent 2,850,858. Filed July 20, 1956. 7 claims. Assigned to U. S. Steel Corp. [Cl. 53-306.]

Emmert, Ernest G. Ink receptive oil transparentized paper. U. S. patent 2,851,378. Filed April 7, 1954. 2 claims. Assigned to Standard Register Co. [Cl. 117-154.] The product is suitable for use as a master in various duplicating processes.

Englert, Joseph A., and Kasey, Bill. Pulp stock valve. U. S. patent 2,851,051. Filed Aug. 22, 1955. 6 claims. Assigned to Crane Co. [Cl. 137-242.] A gate valve is designed to equalize fluid pressure over the body of the valve and thus reduce leakage.

Gish, Lyman C., and Beibers, William M. Art of packaging incandescent lamps and carton therefor. U. S. patent 2,851,158. Filed Nov. 21, 1956. 14 claims. Assigned to Ohio Boxboard Co. [Cl. 206-45.19.] Xmas tree light bulbs may be tested after insertion in the carton before the carton is completely set up.

Grinnell, George G. Sheet binder. U. S. patent 2,850,927. Filed Feb. 11, 1954. 3 claims. [Cl. 77-63.] A machine for drilling holes in a pad of paper is provided with means to prevent burring the outermost sheets during the drilling operation.

Holden, Herbert. Papermaking machines. U. S. patent 2,850,951. Filed May 20, 1954. 16 claims. Assigned to Beloit Iron Works. [Cl. 92-49.] A suction transfer roll arrangement is described.

Hornbostel, Lloyd. Calender stack with individually supported rolls. U. S. patent 2,850,952. Filed March 13, 1956. 5 claims. Assigned to Beloit Iron Works. [Cl. 92-75.]

Kennon, Lloyd, and Swintosky, Joseph V. Cellulose derivative product, compositions comprising the same and their preparation. U. S. patent 2,851,453. Filed Aug. 9, 1954. 4 claims. Assigned to Smith, Kline & French Labortories. [Cl. 260-232.] A method of preparing carboxymethylcellulose is described.

Kramer, Alphonse J., and Painter, Claude D. Carrying carton for cans. U. S. patent 2,851,210. Filed Dec. 26, 1956. 1 claim. [Cl. 229-40.] Improved can-retention means are provided in a sleeve-type carrier.

Mayo, William T., and Henderson, Ernest L. Dispensing device. U. S. patent 2,851,192. Filed April 16, 1953. 1 claim. [Cl. 221-273.] A wall-mounted device is provided for dispensing lids for paper cups.

Mosse, Richard W. E. Bag closing machines. U. S. patent 2,850,856. Filed Dec. 31, 1956. 16 claims. Assigned to Metal Box Co. Ltd. [Cl. 53-89.] Vacuumizing and heat-sealing are accomplished.

Offutt, Harold H. Bag overslip machine. U. S. patent 2,850,855. Filed Aug. 22, 1956. 10 claims. Assigned to Sid Richardson Carbon Co. [Cl. 53-27.] The machine slips an inverted heavy paper bag over articles being moved along a conveyor line.

Palm, Glenn A. Packaging apparatus. U. S. patent 2,850,993. Filed Dec. 3, 1954. 6 claims. Assigned to Metal Specialties Mfg. Co. [Cl. 112-11.] A machine for stitching the mouth of a filled bag is provided with means for including a label in the stitched closure.

Rowe, Howard B. Tape dispensing apparatus having a replaceable gummed tape holder. U. S. patent 2,851,004. Filed June 21, 1955. 1 claim. Assigned to Nashua Corp. [Cl. 118-40.]

Samsing, Rolf A. Display tray blank and container. U. S. patent 2,851,208. Filed April 4, 1955. 5 claims. [Cl. 229-23.]

Schmidt, Walter L. Method for hydrolyzing cellulosic materials. U. S. patent 2,851,382. Filed May 5, 1954. 4 claims. [Cl. 127-37.]

Seragnoli, Ariosto. Stacking mechanism for wrapped tablets and the like. U. S. patent 2,851,172. Filed March 24, 1955. 1 claim. [Cl. 214-7.]

Sherrill, Joseph H. Apparatus for distributing cartons or the like. U. S. patent 2,851,146. Filed Nov. 10, 1955. 12 claims. Assigned to R. J. Reynolds Tobacco Co. [Cl. 198-31.] A single feed stream of empty cigarette cartons is divided into a number of paths or feedways, each equipped with a carton-filling station.

Snyder, Francis H. Preparation of hydroxymethylfurfural from cellulosic materials. U. S. patent 2,851,468. Filed June 10, 1953. 5 claims. Assigned to Dendrol, Inc. [Cl. 260-347.8.]

Staudinger, Johann J. P., and Williams, Howard. Process of impregnating material with a resinous bonding composition. U. S. patent 2,851,379. Filed Nov. 5, 1954. 9 claims. Assigned to Distillers Co. Ltd. [Cl. 117-161.] Mixtures of polyester resins and styrene, useful in laminating, are improved by adding a vinyl chloride polymer or copolymer.

Stephens, Byron T Phthalocyanine pigmented nitrocellulose lacquers. U. S. patent 2,851,371. Filed Feb. 4, 1954. 2 claims. Assigned to Pittsburgh Plate Glass Co. [Cl. 106-193.]

Welshenbach, Charles D. Counter display unit. U. S. patent 2,851,237. Filed Sept. 13, 1954. 3 claims. Assigned to West Virginia Pulp and Paper Co. [Cl. 248-198.] A can or jar stand of paperboard is described.

Zook, Carl E. Auxiliary tag feeding magazine for printing presses. U. S. patent 2,851,269. Filed Oct. 22, 1956. 8 claims. [Cl. 271-28.]

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Ardell, Edgar, Holstebro, Kaye B., and Wozniak, Mitchell S.

Shipping case setting-up and positioning apparatus. U. S. patent 2,851,837. Filed Dec. 28, 1955. 36 claims. Assigned to Emhart Mfg. Co. [Cl. 53-186.]

Bassett, Rex E., Jr. Shielding adhesive tape. U. S. patent 2,852,423. Filed March 18, 1955. 1 claim. Assigned to Bassett Research Corp. [Cl. 154-53.5.] Masking tape laminated to metal foil is used for the protective spiral wrapping of the leads in electrical equipment.

Beeber, Allan R. A., and Gold, Robert M. Blueprint paper. U. S. patent 2,852,377. Filed Nov. 6, 1953. 10 claims. Assigned to Keuffel & Esser Co. [Cl. 96-75.] Finely divided silica is incorporated in the surface of blueprint paper by including it in the sensitizing solution.

Bieler, Jacques L. Container. U. S. patent 2,852,179. Filed Nov. 28, 1955. 2 claims. Assigned to National Dairy Products Corp. [Cl. 229-51.] A cylindrical paperboard cheese container is provided with means which permit the opening and airtight resealing of the container.

Bolding, Hubert V. Cover with display supporting structure. U.S. patent 2,852,178. Filed Sept. 6, 1956. 1 claim. Assigned to Standard Packaging Corp. [Cl. 229-34.] A tray-type single-blank box cover structure includes means for holding a mating bottom section in display position.

Bolding, Hubert V. Spool. U. S. patent 2,852,206. Filed April 24, 1956. 6 claims. Assigned to Standard Packaging Corp. [Cl. 242-118.8.] A single paperboard blank sets up to form a spool for packaging twine, paper, etc.

Bonini, John H., and Hovland, Howard N. Carton. U. S. patent 2,852,133. Filed June 13, 1955. 1 claim. Assigned to American Can Co. [Cl. 206-46.] A carton for butter or the like comprises a flat paperboard box with the upper closure formed by four triangular partially overlapping flaps.

Bradford, William J., Jr., and Schrotenboer, Benjamin Co. Means for making paper box blanks in multiples. U. S. patent 2,851,933. Filed March 17, 1953. 4 claims. Assigned to W. J. Bradford Paper Co. (Cl. 93-58.3.] Complete setup box cover blanks are formed from a web of stock.

Brennan, Edward H. Log loading attachment. U. S. patent 2,852,150. Filed May 18, 1956. 2 claims. Assigned to Barber Machinery Ltd. [Cl. 214-147.] An overhead loader of the tractor type is provided with an attachment which permits more convenient loading of logs from a skid onto a truck.

Brother, George H., and Knowles, Maurice H. Method of fireproofing redwood bark fibers. U. S. patent 2,852,408. Filed Dec. 8, 1955. 4 claims. Assigned to Union Lumber Co. [Cl. 117-66.] The usual fireproofing agents are added to the wet mass of bark, the mass is reduced to shreds, and the shreds are dried for use in building board.

Burman, Joseph O., Jr. Machine for forming and notching strip for box reinforcing rims. U. S. patent 2,852,059. Filed June 24, 1954. 16 claims. Assigned to Progressive Machinery Corp. [Cl. 153-2.] Metal reinforcing strips are formed for jewelry boxes.

Collins, Arthus E. Return ball packaging method. U. S. patent 2,851,835. Filed April 21, 1955. 2 claims. Assigned to Barr Rubber Products Co. [Cl. 53-21.]

Cox, Norman L., and Nicoll, William D. Viscose spinning process. U. S. patent 2,852,333. Filed May 21, 1954. 4 claims. Assigned to E. I. du Pont de Nemours & Co. [Cl. 18-54.]

Crane, Carlton L., and Emerson, John. Method of preparing powdered salt-free cellulose acetate-dicarboxylates. U. S. patent 2,852,507. Filed Feb. 23, 1955. 3 claims. Assigned to Eastman Kodak Co. [Cl. 260-225.]

Dere, Jean R. Basic business form and extensions thereof. U. S. patent 2,852,278. Filed Oct. 13, 1950. 12 claims. [Cl. 283-62.] The perforations and other indicia are scaled to permit use of the forms in countries using either the inch or the metric system of measurement.

Evolfson, Paul. Digester strainer. U. S. patent 2,852,369. Filed Sept. 17, 1954. 8 claims. Assigned to Electric Steel Foundry. [Cl. 92-7.] The frame for each screen section is designed so that it may be cast as a complete unit suitable for use in all commercial digesters.

Faulls, Everett S., Jr., and Rusch, Kenneth A. Art of delivering flexible sheets. U. S. patent 2,852,256. Filed Sept. 9, 1955. 8 claims. Assigned to Milprint, Inc. [Cl. 271-76.] The apparatus delivers sheets of wrapping material cut from a web to a jogging stacker.

Fischer, Paul E. Timed bottom feeder. U. S. patent 2,852,255. Filed May 22, 1953. 8 claims. Assigned to E. G. Staude Mfg. Co., Inc. [Cl. 271-32.] Paper or board blanks are fed from the bottom of a supply stack by means which minimize jamming, duplicate feeding, and operational interruptions.

Frasch, Mary E. Folding paperboard box construction. U. S. patent 2,852,177. Filed March 13, 1956. 1 claim. [Cl. 229-15.] Hinged body and lid elements, formed from a single blank, meet along outwardly turned flanged edges, with a separate blank dividing the box into two compartments.

Fromwiller, Edward. Automatic butter pat dispenser. U. S. patent 2,851,836. Filed March 31, 1953. 22 claims. [Cl. 53-59.] The machine forms paper trays, places a butter pat on each tray, and stacks the filled trays in a preformed container.

Gaebel, Reinhold, and Neugebauer, Helmut. Preparation of thin sections of material from melts of cellulose esters. U. S. patent 2,852,332. Filed March 30, 1954. 3 claims. Assigned to Hercules Powder Co. [Cl. 18-54.]

George, Harvey F. Sheet collating machine. U. S. patent 2,852,250. Filed Oct. 9, 1953. 18 claims. Assigned to Davidson Corp. [Cl. 270-58.] Improper feeding or jamming results in corrective action or machine halting.

Goodner, James R. Bag holder. U. S. patent 2,852,045. Filed July 16, 1956. 5 claims. Assigned to Great Western Sugar Co. [Cl. 141-314.] A bag-filling machine is provided with an apparatus which holds the bag mouth in proper position for subsequent stitching.

Hausner, Johann K. Control of cellulose precipitation bath concentrations. U. S. patent 2,852,453. Filed Oct. 21, 1955. 3 claims. [Cl. 204-131.] A d.c. field is imposed on a viscose spinning bath and a high frequency field is then superimposed on the d.c. field.

Heywood, Vincent E. Manufacture of envelopes. U. S. patent 2,851,934. Filed July 10, 1957. 8 claims. Assigned to United States Envelope Co. [Cl. 93-62.] An improved glue application method permits high-speed production with no limit on size or shape of the envelopes.

Hiatt, Gordon D., and Crane, Carlton L. Precipitation of dicarboxylic acid esters of cellulose ethers and lower fatty acid esters. U. S. patent 2,852,508. Filed March 20, 1956. 7 claims. Assigned to Eastman Kodak Co. [Cl. 260-226.]

Himes, Charles R., and Lanphear, Vernon T. Machine for wrapping rolls of paper and the like. U. S. patent 2,851,839. Filed June 18, 1956. 10 claims. Assigned to Kalamazoo Vegetable Parchment Co. [Cl. 53-380.]

Hollihan, John P., Jr., Howsmon, John A., and Sisson, Wayne A. Method of producing viscose rayon. U. S. patent 2,852,334. Filed Nov. 3, 1954. 6 claims. Assigned to American Viscose Corp. [Cl. 18-54.] Smooth-surface all-skin rayon filaments are produced from a viscose to which has been added an alkylene oxide adduct of a primary 8–18 carbon fatty amine.

Inman, William H. Collapsible carton. U. S. patent 2,852,180. Filed Dec. 16, 1957. 4 claims. Assigned to Bloomer Bros. Co. [Cl. 229-51.] Improved closure and opening means are provided for an automatic bottom ice cream carton.

Johnson, Kenneth R. Infusion package. U. S. patent 2,852,389. Filed Aug. 6, 1954. 4 claims. Assigned to Bartelt Engineering Co. [Cl. 99-77.1.] In a paper tea-bag construction, the string element joining tag and bag is concealed within the plies of the tag, which is heat-sealed to the bag until required for use.

Leitzel, Ammon M. Porous sintered metal molding die. U. S. patent 2,851,931. Filed April 4, 1955. 5 claims. Assigned to Pacific Pulp Molding Co. [Cl. 92-54.] A die for forming molded pulp articles such as egg fiats and the like is described.

McIntyre, Thomas W., and Smith, Archibald H. Packaging machines. U. S. patent 2,851,838. Filed March 9, 1956. 9 claims. Assigned to Mac, Inc. [Cl. 53-189.] In a bagging machine, guide arms enter the opened bag to hold it open while an article is inserted.

Metzig, Harvey F., and Clark, Byron S. Stone mounting for pulp-wood grinder. U. S. patent 2,851,830. Filed March 30, 1956. 10 claims. [Cl. 51-206.4.]

Prohaska, James J. Printing machine. U. S. patent 2,851,944. Filed Sept. 19, 1955. 7 claims. [Cl. 101-44.] A semiautomatic device imprints labeling data on bags and other packages.

Roach, Earl M. Collapsible display. U. S. patent 2,851,804. Filed Sept. 17, 1956. 5 claims. Assigned to Arvey Corp. [Cl. 40-126.] A display device consists of a pleated paperboard backing sheet framed by suitably disposed panels and held in setup condition by the tension of rubber bands.

Robbins, Frederick O., Sweeder, Joseph, Dunbar, Willis, and Wolke, Raymond W. Masking envelope for space reservation tickets. U. S. patent 2,852,277. Filed Aug. 14, 1953. 3 claims. Robbins and Sweeder's interests assigned 25% to Pennsylvania Railroad Co. and 25% to New York Central Railroad. [Cl. 283-23.]

Satterthwaite, Robert W. Process of making starch mobile and hydrophobic. U. S. patent 2,852,404. Filed Dec. 1, 1955. 6 claims. Assigned to Corn Products Refining Co. [Cl. 106-211.] The starch product is useful as an antisetoff spray in printing and as an adhesion prevention compound for application to the inner walls of containers.

Shell, Francis J. Cement composition. U. S. patent 2,852,402. Filed Jan. 3, 1955. 13 claims. Assigned to Phillips Petroleum Co. [Cl. 106-93.] Sodium carboxymethylhydroxyethylcellulose is used.

Sperry, Paul A. Sheet material feed control means and

method. U. S. patent 2,852,252. Filed June 13, 1952. 8 claims. [Cl. 271-2.1.] The feeding means for a web-cutter or other machine is provided with means to regulate closely the feeding rate so as to compensate for dimensional changes in the material.

Steck, Rudolph E., and Orzechowski, John F. Friction material. U. S. patent 2,852,368. Filed Aug. 13, 1954. 2 claims. Assigned to Raybestos-Manhattan, Inc. [Cl. 92-3.] Stock for transmission friction material is formed from a furnish of asbestos, wood particles, sulphite pulp, starch, and clay.

Tauber, Rudolf. Tab applying machine. U. S. patent 2,851,932. Filed May 3, 1956. 7 claims. [Cl. 93-1.] The machine applies plastic indexing tabs to the edges of sheets of paper.

Thornsberry, Herman F. Carton filler, U. S. patent 2,852,044. Filed Jan. 11, 1957. 1 claim. Assigned to T and C Mfg. Co. [Cl. 141-144.] A turntable apparatus fills cartons with peas or other pourable produce.

Volberg, Frank M., and Martin, Melvin D. Washing of cellulose esters in treated sodium zeolite water. U. S. patent 2,852,509. Filed Dec. 1, 1955. 8 claims. Assigned to Eastman Kodak Co. [Cl. 260-230.]

Wahl, Otto, and Bradford, Charles L. Means for making paper partitions. U. S. patent 2,852,074. Filed Jan. 27, 1953. 3 claims. Assigned to W. J. Bradford Paper Co. [Cl. 164-12.] Box partitions are formed so that the grain runs longitudinally in all strips.

Wilhelmi, Hans, and Neudert, Walter. Production of multilayer boards. U. S. patent 2,851,730. Filed Oct. 7, 1953. 10 claims. Assigned to Firma Holzwerke H. Wilhelmi O. H. G. [Cl. 18-47.5.] Wood particle board is formed so that the surface is denser than the core.

Yaeger, Luther L. Cellulose mixed ester coating composition. U. S. patent 2,852,403. Filed Dec. 28, 1955. 3 claims. Assigned to American Motors Corp. [Cl. 106-178.] Cellulose acetate butyrate is used in a composition for coating polystyrene plastics.

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Bauer, Gerald C. Collapsible container. U. S. patent 2,853,225. Filed Aug. 22, 1956. 1 claim. Assigned to Cellu-Kote, Inc. [Cl. 229-58.] A collapsible paper container for roofing asphalt is formed from material coated on one side with an adhesion-prevention compound, the stapled seams of the container being designed to prevent leakage.

Bitterman, Marie L., and Taylor, John W. Page corner mark for books. U. S. patent 2,853,043. Filed March 5, 1956. 1 claim. [Cl. 116-119.]

Bowman, Paul F. Carton opening device. U. S. patent 2,852,988. Filed April 20, 1955. 2 claims. Assigned to Continental Paper Co. [Cl. 93-51.] A paperboard tomato tray is constructed so that it may be set up on automatic machinery without the use of adhesives.

Brown, Justin W. Apparatus and process for filling bags. U. S. patent 2,853,105. Filed April 26, 1956. 6 claims. Assigned to Chattanooga Boiler & Tank Co. [Cl. 141-285.] A resiliently extensible bag-filling spout construction permits lowering of the filled bag to the discharge conveyor without loss of the material being packaged.

Buehlig, William W. Combination measuring and direct pouring dispenser for granular materials. U. S. patent 2,853,213. Filed Sept. 6, 1955. 2 claims. [Cl. 222-455.] A plastic measuring and pouring dispenser is attached to the outside of a paperboard carton for household soap powder and the like.

Chaplin, Oliver F., and Berney, Joseph C. Stacker and delivery mechanism for paper products and the like. U. S. patent 2,852,989. Filed Aug. 9, 1954. 1 claim. Assigned to Crown Zellerbach Corp. [Cl. 93-93.] The mechanism is especially for a machine which combines sheets of paper to form a pad for use in packaging fruit.

Christian, Moss B. Wood particle veneer board and method of making same. U. S. patent 2,853,413. Filed Sept. 13, 1954. 8 claims. Assigned to Chicago Mill and Lumber Co. [Cl. 154-132.] A veneer core is faced with layers of wood particle board in which the fibers are oriented at right angles to the grain of the veneer.

Cusi, Dante S. Agitation device. U. S. patent 2,853,280. Filed Dec. 7, 1954. 5 claims. Assigned to International Pulp Products, Inc. [Cl. 259-96.] In a mechanical pulper embodying a horizontal rotating disk, a gas layer is maintained beneath the disk to reduce friction and power requirements.

Domenech, Michael. Electrocardiographic card mount. U. S. patent 2,852,878. Filed Oct. 22, 1953. 1 claim. [Cl. 40-158.] Electrocardiographic negatives are secured within envelope devices held within slots provided in a mounting folder.

Douglas, Ollie G. Log loading device. U. S. patent 2,853,198. Filed Jan. 4, 1957. 2 claims. Assigned 25% to Edward Gunning and 25% to Joseph D. Gunning. [Cl. 214-77.] A power-operated device, hinged to the side of a truck, is adapted to load the bed of the truck with logs.

Egleston, Harry B., and Smith, Donald E. Flat top carton infeed unit for filling machine. U. S. patent 2,852,900. Filed March 24, 1955. 10 claims. Assigned to Ex-Cell-O Corp. [Cl. 53-382.]

Faeber, Harry W. Jogger mechanism. U. S. patent 2,853,298. Filed Nov. 21, 1955. 6 claims. Assigned to Time, Inc. [Cl. 271-87.] Printed signatures delivered in overlapping fashion from a folding machine are jogged, assembled, and aligned.

Faeber, Harry W. Stream feeder device. U. S. patent 2,853,297. Filed April 22, 1954. 7 claims. Assigned to Time, Inc. [Cl. 271-11.] Rotary gripper mechanisms are provided in machines for stream-feeding signatures to collating machines.

Gallagher, John P. Insulated foil lined paper cup. U. S. patent 2,853,222. Filed April 20, 1953. 7 claims. [Cl. 229-1.5.]

Guyer, Reynolds. Can holding carton. U. S. patent 2,853,183. Filed April 15, 1955. 1 claim. Assigned to Waldorf Paper Products Co. [Cl. 206-47.] A paperboard device retains a can while flanges of the device permit attachment of the assembly to the top of a paperboard carton.

Hermanson, William A., and Hermanson, Gerald I. Porous paper powder puff package. U. S. patent 2,852, 795. Filed May 3, 1955. 6 claims. [Cl. 15-131.1.]

Holmberg, Lawrence O. Can carrier. U. S. patent 2,853,186. Filed Nov. 2, 1954. 4 claims. [Cl. 206-65.] A paperboard band with chime-engaging slots is secured tightly about two stacks of cans.

Jones, John P. Sheet folding machine. U. S. patent 2,853,293. Filed May 19, 1955. 2 claims. [Cl. 270-79.] The machine folds a flexible sheet of paper or other material upon itself in predetermined folded lengths.

Link, Peter J., and Nelson, Douglas G. Layboy. U. S. patent 2,853,299. Filed April 5, 1954. 16 claims. Assigned to Kimberly-Clark Corp. [Cl. 271-88.] The insertion of a temporary sheet-receiving support into the feed stream is made possible without interfering with the delivered sheets.

Lolkema, Jan, and Moes, Geert. Method of preparing cold swelling starch ethers and/or esters. U. S. patent 2,853,484. Filed Nov. 14, 1955. 10 claims. Assigned to Naamloze Vennootschap W. A. Scholten's Chemische Fabrieken Groningen. [Cl. 260-233.3.] The products are of use in adhesives, paper sizes, etc.

Lowey, Hans. Ethyl cellulose coatings for shaped medicinal preparations. U. S. patent 2,853,420. Filed July 19, 1956. 8 claims. [Cl. 167-82.]

Murrell, Harvey S. Collar feeding mechanism. U. S. patent 2,852,899. Filed March 16, 1954. 15 claims. [Cl. 53-198.] Paper collars are fed from a nested supply stack and placed about the necks of filled bottles.

Norman, Noel E., and Maddern, Richard W. Method and apparatus for removing sample or test pieces from traveling sheet material. U. S. patent 2,853,133. Filed May 24, 1954. 11 claims. Assigned to Australian Paper Mfrs. Ltd. [Cl. 164-17.] An air-pressure apparatus fires a hollow cylindrical missile through the moving web on a paper machine to capture a sample from the web.

Osborn, Robert O. Cellulosic sponge process. U. S. patent 2,853,395. Filed March 12, 1954. 2 claims. Assigned to E. I. du Pont de Nemours and Co. [Cl. 106-122.] Hemp or jute fibers are dispersed in aqueous caustic and the dispersion is mixed with cellulose xanthate to form a mixture suitable for use in making cellulosic sponge.

Paflas, Andrew D. Container sealing cover. U. S. patent 2,853,223. Filed April 26, 1955. 2 claims. [Cl. 229-14.] The closure construction of a lined paperboard box for potato chips and the like is designed to permit reclosure of the carton moisture-tight condition.

Riley, Nelson F. Elastic paper backed cushioning material. U. S. patent 2,853,411. Filed March 21, 1955. 3 claims. Assigned to United States Rubber Co. [Cl. 154-49.] A rug underlayment comprises a layer of sponge rubber laminated to a layer of stretchable water-repellent paper.

Roe, John E. Separation or batching of substantially flat sheets of material continuously emerging from a machine. U. S. patent 2,852,990. Filed May 24, 1955. 4 claims. Assigned 50% to St. Clements Press Ltd. [Cl. 93-93.] A stream of newspapers delivered from a printing press is separated into counted groups.

Rollie, Robert D. Damage-resistant packages. U. S. patent 2,853,185. Filed April 19, 1957. 6 claims. Assigned to Minnesota Mining and Mfg. Co. [Cl. 206-52.] Devices formed of paperboard and sheet metal are located at opposite ends of a dispensing carton for rolled sheet material to engage and support the roll core.

Sabee, Reinhardt N. Guide roll. U. S. patent 2,853,295. Filed Oct. 28, 1954. 13 claims. [Cl. 271-2.6.] An improved paper machine guide roll corrects for lateral drift of wire or felt.

Schanz, Karl. Process and machine for producing rods for tobacco filters. U. S. patent 2,852,987. Filed Aug. 3, 1953. 12 claims. Assigned to Papierfabrik Fleischer G. m. b. H. [Cl. 93-1.] The filters are of tissue paper.

Shapero, Wallace H. Flexible tube container and method of making the same. U. S. patent 2,853,187. Filed March 29, 1954. 2 claims. Assigned to Wallace Container Co. [Cl. 206-80.] Paints, etc., are sealed in a plastic tube, a flap of which is then stapled to a paperboard display card.

Skow, Ross E. Mechanism for supplying workpieces such as envelopes to the feeding mechanism of a printing press. U. S. patent 2,853,296. Filed March 2, 1956. 16 claims. Assigned to Walbert Machine Co. [Cl. 271-5.]

Slater, Robert, and Zach, Ella. Box handle and closure. U. S. patent 2,853,224. Filed Jan. 26, 1956. 3 claims. Assigned 50% to Paul O. Tobeler. [Cl. 229-52.] A separate handle element is passed through flaps cut through the walls of the deeply telescoping lid and body elements of a paperboard box, thus locking the container.

Smith, Leon E. Match case. U. S. patent 2,853,184. Filed March 5, 1956. 1 claim. [Cl. 206-48.] A paperboard matchbook includes a storage chamber for a pack of cigarettes.

Stickle, Frederick A. Automatic steam control for paper machines. U. S. patent 2,852,860. Filed May 18, 1955. 12 claims. Assigned to Stickle Steam Specialties Co. [Cl. 34-49.]

Thumm, Byron A. Viscose spinning process. U. S. patent 2,853,360. Filed Nov. 3, 1954. 6 claims. Assigned to American Viscose Corp. [Cl. 18-54.] Smooth all-skin filaments are formed from a viscose containing minor amounts of water-soluble alkylene oxide adducts of morpholine.

Werner, Jesse, and Hessel, Frederick A. Process of reacting carbohydrates with various reagents in the presence of 2-pyrrolidone or N-methyl-2-pyrrolidone. U. S. patent 2,853,485. Filed May 19, 1955. 14 claims. Assigned to General Aniline & Film Corp. [Cl. 260-234.]

Western, Arthur W., and Taylor, Walter. Couch roll structure for paper making machines. U. S. patent 2,852,986. Filed June 22, 1953. 16 claims. Assigned to Empire Paper Mills Ltd. [Cl. 92-47.] Means are provided for the continuous automatic detection of the position of draw.

Woodcock, Edward C. Web processing apparatus. U. S. patent 2,853,294. Filed Dec. 23, 1957. 13 claims. Assigned to Williamson Mfg. Co. Ltd. [Cl. 271-2.2.] In apparatus where the web is led up and down over guide rollers, automatic web-threading apparatus is provided.

Zabriskie, Douglas M., and Moore, William F. Spindleless paper roll holder. U. S. patent 2,853,251. Filed April 16, 1957. 8 claims. Assigned to Western Union Telegraph Co. [Cl. 242-68.4.] The paper roll holder is for use in electric-recording apparatus and the like.

Sept. 30, 1958

Anderson, Arthur W., Moeller, Bernhard V., and Weymouth, Merrill H. Method for the preparation of cold-water-soluble forms of cellulose ethers. U. S. patent 2,854,448. Filed March 19, 1956. 9 claims. Assigned to Dow Chemical Co. [Cl. 260-232.]

Beach, William I. Postforming process. U. S. patent 2,854,373. Filed July 22, 1952. 2 claims. Assigned to North American Aviation, Inc. [Cl. 154-110.] Resin-impregnated paper designed to be three-dimensionally shaped is attached to a suitable structural backing membr before the shaping process.

Clark, Charles K., and Nason, Robert O. Treating floating soap and product obtained thereby. U. S. patent 2,854,419. Filed Jan. 21, 1955. 14 claims. Assigned to Crossett Chemical Co. [Cl. 252-368.] Black liquor soap skimmings are dried, heated, and compressed to form a powdery material of use in drilling fluids and other applications.

Clark, Charles K., and Nason, Robert O. Treating tall oil soap and product obtained thereby. U. S. patent 2,854,420. Filed Dec. 22, 1955. 14 claims. Assigned to Crossett Chemical Co. [Cl. 252-368.] Black liquor soap skimmings are treated with sulphuric acid, the product saponified with sodium hydroxide and the sodium tallate processed as in U. S. patent 2,854,419 (Sept. 30, 1958).

Clevy, Roland, and Robin, Jean. Continuous process for the esterification of cellulose in homogeneous phase. U. S. patent 2,854,445. Filed March 5, 1957. 2 claims. Assigned to Societe Rhodiaceta. [Cl. 260-214.]

Di Padova, Lucy K. Collapsible hat box. U. S. patent 2,854,050. Filed Feb. 11, 1957. 4 claims. Assigned 50% to James J. Cannon. [Cl. 150-1.] Paperboard box-forming elements are enclosed within a drawstring-closed babric bag.

Dodd, Geoffrey J. Windowed carton with integral dividers. U. S. patent 2,854,182. Filed Dec. 19, 1955. 6 claims. Assigned to Cornell Paperboard Products Co. [Cl. 229-27.]

Donaldson, Chase. Plastic tubing. U. S. patent 2,854,031. Filed Jan. 26, 1954. 9 claims. [Cl. 138-78.] The tube is formed from a base layer of resin-impregnated paper and a surface layer of glass fibers bonded to the base layer by the same resin.

Foster, Mitchell E., and Purcer, Alan H. Collapsible container. U. S. patent 2,854,165. Filed Oct. 13, 1954. 2 claims. Assigned to Packing Material Co., Inc. [Cl. 217-3.] A wood-reinforced collapsible corrugated shipping container includes in its bottom construction a wooden pallet.

Goodman, Peter J. Carton dispenser. U. S. patent 2,854,169. Filed Dec. 19, 1955. 3 claims. [Cl. 221-104.] Erected opened egg cartons are fed from a stack to a filling machine.

Groeper, Lawrence H. Paper folding machine. U. S. patent 2,854,233. Filed June 19, 1956. 14 claims. [Cl. 270-79.] A web of recording paper is folded into zigzag or accordion-folded form.

Hash, James M. Injector hatchet. U. S. patent 2,853,833. Filed March 23, 1956. 3 claims. [Cl. 47-57.5.] Means embodied within the handle and head of a hatchet force fluid into a tree each time the hatchet is plunged into the tree.

Heine, William H. Easily openable carton top. U. S. patent 2,854,184. Filed April 30, 1956. 1 claim. Assigned to Kellogg Co. [Cl. 229-51.] The top closure flaps of a paperboard cereal box are arranged to cooperate with a line of weakening to permit easy rupturing and opening of the top panel dispensing opening.

Herrmann, Alvin G. Wrapper-applying apparatus. U. S. patent 2,853,839. Filed Sept, 24, 1954. 14 claims. Assigned to Contemporary Machine Designers, Inc. [Cl. 53-32.] The apparatus adhesively seals a paper sleeve about a magazine, newspaper, or the like.

Humphrey, Ethel L. Tissue dispenser. U. S. patent 2,854,134. Filed Aug. 22, 1955. 1 claim. [Cl. 206-57.] A device having suction cups permitting attachment to another surface holds a paperboard container filled with paper tissue sheets.

Kaddeland, Christen R. Means for feeding cut sheets in lapped sequence. U. S. patent 2,854,236. Filed April 8, 1953. 1 claim. Assigned to Miehle-Goss-Dexter, Inc. [Cl. 271-75.] Paper sheets cut from a web are overlapped, registered, and fed to a printing press.

Madsen, Abner L. Coat hanger cover applying machine. U. S. patent 2,853,840. Filed Aug. 24, 1956. 7 claims. [Cl. 53-200.]

Monson, Louis T., and Dickson, Woodrow J. Process for preparing oxyalkylated derivatives. U. S. patent 2,854,447. Filed June 4, 1953. 8 claims. Assigned to Petrolite Corp. [Cl. 260-232.] A process of preparing oxyalkylated derivatives of cellulose compounds such as alkali cellulose, carboxymethylcellulose, etc., is described.

Monson, Louis T., and Dickson, Woodrow J. Process for preparing oxyalkylated derivatives. U. S. patent 2,854,449. Filed June 4, 1953. 8 claims. Assigned to Petrolite Corp. [Cl. 260-233.3.] The process of U. S. patent 2,854,447. (Sept. 30, 1958) is applied to starch, amylose, dextrin, inulin, etc.

Nichols, Robinson F. Composition comprising diisocyanate-linked elastomers and lignin. U. S. patent 2,854,422. Filed Feb. 1, 1955. 5 claims. Assigned to B. F. Goodrich Co. [Cl. 260-17.5.] Alkali lignin from black liquor is employed as an extender in elastomeric vulcanizates.

Pantalone, Vincent R. Packing and display containers. U. S. Patent 2,854,135. Filed Aug. 9, 1956. 3 claims. Assigned to Federal Paper Board Co., Inc. [Cl. 206-79.] Flaps bent inward from the edges of a window opening in a display carton grip the article to be displayed between them.

Phillpotts, George C. Copying sheet, method of making and using same. U. S. patent 2,854,350. Filed July 7, 1954. 14 claims. Assigned to Caribonum Ltd. [Cl. 117-36.] A sheet of paper is coated so that locally applied pressures produce an image in the area of pressure.

Robin, Jean, and Clevy, Roland. Process for the continuous production of cellulose esters. U. S. patent 2,854,446. Filed Nov. 8, 1956. 6 claims. Assigned to Societe Rhodiaceta. [Cl. 260-229.]

Shea, James R., Jr. Means for removing a lift of sheet material from a stack of such material. U. S. patent 2,854,150. Filed May 1, 1957. 4 claims. Assigned to West Virginia Pulp and Paper Co. [Cl. 214-1.] A hollow perforated sword-like blade supplied with compressed air is inserted into a stack of paper to facilitate lifting the sheets above the sword from the stack.

Shields, Albert F. Drive for box blank gripping and feeding mechansims in cutting and creasing presses. U. S. patent 2,853,927. Filed May 17, 1956. 7 claims. Assigned to S & S Corrugated Paper Machinery Co., Inc. [Cl. 93-58.3.]

Smith, William C. Carton. U. S. patent 2,854,181. Filed Feb. 5, 1954. 3 claims. Assigned to W. C. Ritchie and Co. [Cl. 229-27.] An extra inner diagonal flap within a paperboard carton for a bottle or tube prevents the carton contents from falling out if the bottom closure is accidentally opened.

Srofe, Jesse. Packaging and merchandising device. U. S. patent 2,854,183. Filed April 8, 1957. 3 claims. [Cl. 229-34.] A shallow paperboard tray is provided for the unitized packaging of a row of cans.

Steen, Harford K. Handled carrying bags. U. S. patent 2,854,185. Filed Feb. 23, 1955. 6 claims. Assigned to Interstate Bag Co., Inc. [Cl. 229-54.] A paper handle strap for a paper bag is designed to provide means for locking the bag mouthclosed.

Swann, Erwin D. Costume convertible shopping bag. U. S. patent 2,853,710. Filed May 3, 1955. 5 claims. [Cl. 2-243.] A paper shopping bag converts into a child's play costume.

Swart, Gilbert H., and Earley, Paul J. Aluminum resinate rubber composition and method of making the same. U. S. patent 2,854,423. Filed May 27, 1954. 4 claims. Assigned to General Tire and Rubber Co. [Cl. 260-27.] Rosin and aluminum salts of rosin acids are employed as extenders in synthetic rubber compositions.

Triolo, Louis. Tape applying machine. U. S. patent 2,-854,164. Filed June 5, 1957. 9 claims. [Cl. 216-29.] An apparatus applies short lengths of pressure-sensitive tape about the edges of a folder in making paperboard phonograph record holders.

Vredenburg, Edric W. Apparatus for filling and closing bags. U. S. patent 2,853,842. Filed June 27, 1955. 20 claims. Assigned to St. Regis Paper Co. [Cl. 53-384.] Resilient members carry and support a bag, urging the bag mouth closed while still permitting the entry and withdrawal of a filling nozzle.

Wertheimer, Milton A. Wrapping and sealing machine. U. S. patent 2,853,841. Filed Nov. 15, 1957. 5 claims. Assigned to Gellman Mfg. Co. [Cl. 53-210.] Various improvements are described in a machine for automatically wrapping and sealing an article in heat-sealable paper.

Wilkerson, Fenton E. Log handling device. U. S. patent 2,854,280. Filed Sept. 21, 1956. 9 claims. [Cl. 294-82.] Power-operated means permit rolling a felled log onto a choker which is then secured about the log so that it may be snaked from the woods.

Williams, Russell J. Bag. U. S. patent 2,854,186. Filed March 15, 1954. 7 claims. Assigned to Bemis Bro. Bag Co. [Cl. 229-55.] Reinforcing patch elements are provided in the vicinity of the closures of a multi-ply paper bag.

Wilson, Harry W. Method of applying dressing for prolonging the effective life of cloth belts and resultant article. U. S. patent 2,854,351. Filed June 9, 1953. 7 claims. [Cl. 117-44.] The life of cloth belts used in making corrugated board is increased by impregnating the edges with a mixture of graphite and butadiene-styrene copolymer.

Yan, Maxwell M., and Borchers, Henning H. Process for forming wood particle board and product. U. S. patent 2,-854,372. Filed Aug. 31, 1954. 10 claims. Assigned to Abitibi Power & Paper Co., Ltd. [Cl. 154-101.]

RECENT BOOKS

Problems in Wood Chemistry. Weizmann Science Press of Israel, Jerusalem. (Interscience Publishers Inc., Agents). Buckram, $6^1/_2 \times 9^1/_2$, 137 pages. $6.00.

The lectures given at the seventh session of the technical panel on wood chemistry of the U.N. Food and Agriculture Organization, April 8–13, 1956, in Israel. Participants included H. Mark, H. W. Giertz, M. Lewin, K. Freudenberg, E. C. Jahn, E. Ott, and C. A. Heiberger. Among lectures given were: Radiation Chemistry, Properties of the Compound Middle Lamella, Middle Lamella of Bast Fibers, Carbohydrate-Lignin Bonding, Principles of Adhesion.

Modern Methods of Mechanical Pulp Manufacture. By K. H. Klemm (Translated by E. P. Chin). Lockwood Trade Journal Co., New York, 1958. Cloth, 6×9, 241 pages. $5.00.

An excellent contribution to the sparse literature relating to groundwood manufacture. The text was originally published in German in 1957. In the translation several corrections were made and the text enlarged and brought up to date by consideration of groundwood production from chips. The text ran serially in the *Paper Trade Journal*. Many persons will welcome the book in its present bound form. The text is divided into three main categories. Wood, The Groundwood Mill, and Groundwood Stock Preparation.

Fundamentals of Papermaking Fibers. Edited by Francis Bolam, Technical Section, British Paper and Board Makers' Association, St. Winifred's, Welcomes Road, Kenley, Surrey, England, 1958. Cloth, $5^1/_2 \times 8^1/_2$, 487 pages. (Obtainable from the Technical Section, B. P. & B. M. A.)

The British Technical Section has performed a valuable service in issuing the transactions of its symposium held at Cambridge, England, in September, 1957, in book form. In addition to the presentation of the papers presented the discussions following these presentations are also recorded.

The text covers four major categories: 1. The Morphology of Pulp Fibers; 2. The Chemistry of Pulp Fibers; 3. Properties of Bonded Fiber Assemblages; and 4. The Process of Beating.

Eighteen papers are presented by such well-known scientists as A. Frey-Wyssling, H. Bucher, H. W. Emerton, B. G. Ranby, L. Jorgensen, P. Lange, H. E. Dadswell, B. Steenberg, W. Brecht, H. Corte, L. Nordman, W. Gallay, H. W. Giertz, G. Centola, J. A. Van den Akker, and S. G. Mason most of whom have appeared in earlier TAPPI Fundamental Research Conferences.

The purpose of the symposium was to assemble the world's experts for a critical review of their chosen subjects in order to enhance the understanding of the beating process.

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E459-59 Paper Converting: 16 yr. industrial experience of which 11 yr. were in coatings, coated papers, and coated cup and food container fabrication. Extensive experience in converting polyethylene and vinyl coated papers, applying polyethylenes and vinyls to fabricated products. Managerial experience.

E460-59 Technical Director—Chief Chemist. Young, responsible—well grounded in all phases of kraft (bleached and natural) operations and control—process and feedwater treatment. Willing and able to train and supervise others. Seeks association with concern truly interested in upgrading its technical department.

E461-59 Paper Technologist, college graduate 37 years of age with broad chemical engineering cross-sectional operational, development, and service experience from pulping to deinking for fine, book, conversion, and insulating board fields including coating and adhesives. Presently midwest. Desire permanent southern location.

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P808-58. Wanted-Chemical Engineer or Chemist with paper testing and mill experience for Middle West consulting firm.

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P815-59 Chemical Engineer with 1–2 years experience for process development lab in Southern New England. Multiplant manufacturer of paper products.

P816-59 Chemist or Chemical Engineer—3–5 years experience in bleached kraft and/or specialty paper mill for an Ontario integrated bleach kraft pulp and paper mill. Involves work in mill control and/or process control and development. Please furnish complete particulars as to age, experience, marital status, references, and salary.

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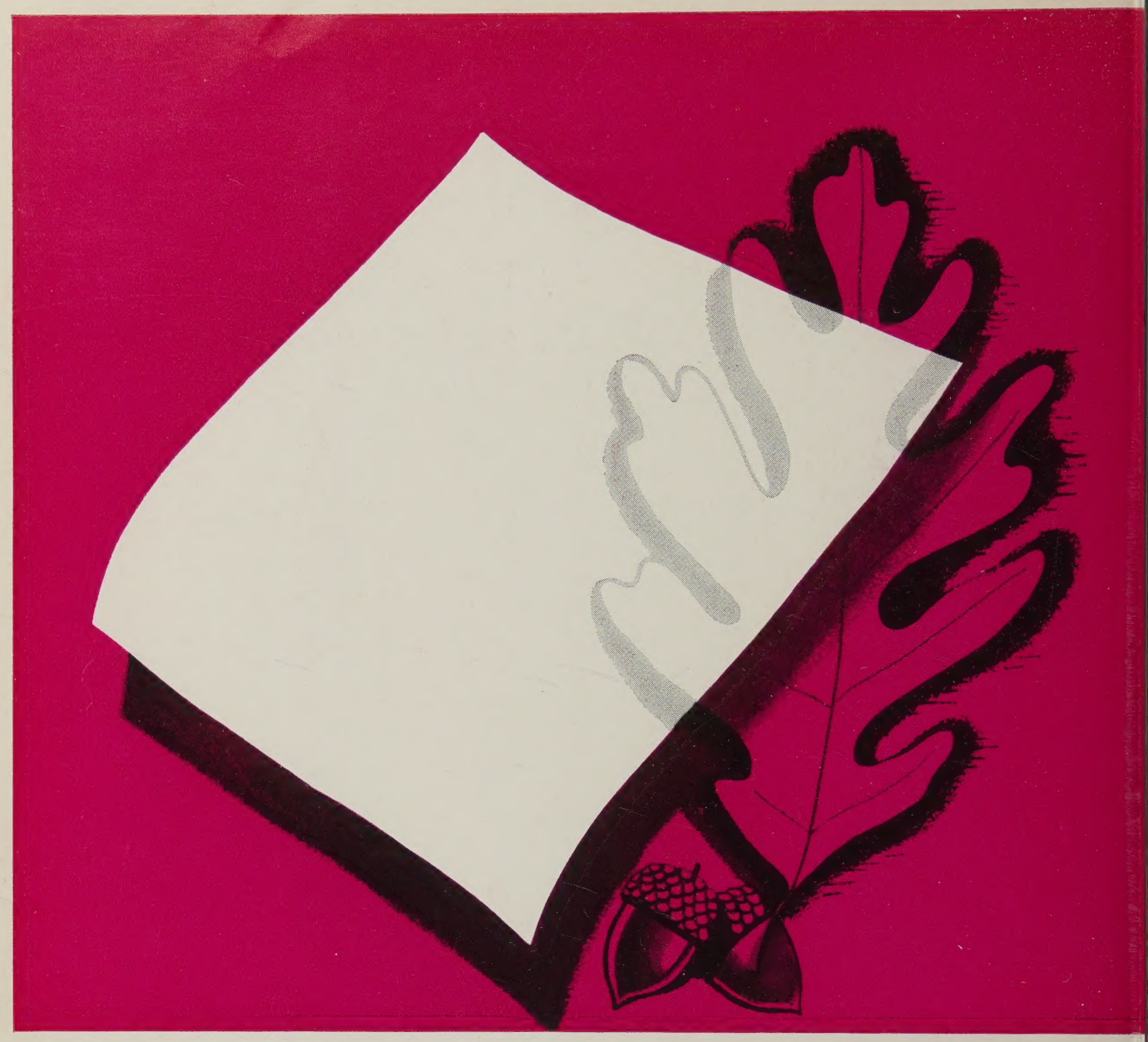

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